NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY

NGA.SIG.0033_1.0.1_ELEV
2019-08-22
Inc. Adm. Chg. 1 2019-09-30

NGA STANDARDIZATION DOCUMENT

Digital Elevation Content Standardization Implementation Guidance (2019-08-22)

Incorporating Administative Change 1
2019-09-30

Version 1.0.1

NATIONAL CENTER FOR GEOSPATIAL INTELLIGENCE STANDARDS

Table of Contents

Table of Figures

Table of Tables

Introduction

NGA has authored this Standardization Implementation Guidance (SIG) to support the requirement for a uniform model for geospatial elevation data. A uniform model will help align a wide range of geospatial resolutions and input data sources, ensuring interoperability between elevation product implementations. Elevation models are important for mission planning, hydrological analysis, and other related applications. They are often fused with other geospatial products to enhance visualization capabilities for analysts, mission planners, and warfighters. Consistent file formatting, standardized data structure, and a comprehensive metadata schema are essential for realizing these missions.

Revision History

Version	Approval Date	POC	Change Description
1.0	2019-08-22	WMN	Initial Release
1.0.1	2019-09-30	WMN	Administrative changes: 1. Update Table of Contents – page numbers only 2. Updated version, date information on title page 3. Updated page headers

1 Scope

This Standardization Implementation Guidance (SIG) specifies a common data model and metadata schema for the exchange of elevation data within the National System for Geospatial Intelligence (NSG) that is compatible with existing software production environments, cloud computing systems, and NSG metadata standards. It does not specify how elevation data should be collected or used. The National Geospatial-Intelligence Agency (NGA) intends for this guidance to assist elevation data producers and consumers in interpreting the abundance of NSG, defense, and international geospatial data and metadata standards (see Section 2), in order to support data interoperability across the NSG. Future work needs to address the alignmnent of elevation tiles with other NSG-mandated tile structures and 3D content services.

As geospatial data are migrated to the cloud for dissemination across a wide variety of systems, file formats, and operating environments, it is imperative to provide robust metadata that is data format-agnostic and is compatible with existing content models that other software platforms and end-user systems recognize and interpret. For this purpose, the NGA specifies a core set of geospatial metadata requirements called the NSG Metadata Foundation (NMF: NGA.STND.0012_3.0_NMF), which is applicable to all data and software service resources across the NSG. The NMF is a profile of the much broader NSG Application Schema (NAS), which is a unified logical data model, based partly on the ISO 19100 series of geographic standards and multiple U.S. Intelligence Community (IC) technical specifications. Part 1 of the NAS is a platform-independent model for geospatial content and metadata (NGA.STND.0022_8.0_NAS).

This SIG specifies the NSG Elevation Metadata Implementation Specification (NEMIS), whose adoption and use ensures full conformance with the NAS, associated ISO 19100-series standards, and IC Data Encoding Specifications (DES). The NEMIS also satisfies the metadata requirements of the Defence Geospatial Information Working Group (DGIWG) Defense Gridded Elevation Data (DGED) implementation profile for gridded elevation data (DGIWG – 250), ensuring that conformant data products are compatible with other gridded elevation content in the broader international Defense community.

The NEMIS metadata schema is specified using Unified Modeling Language (UML) class diagrams and an accompanying data dictionary. This logical model has been realized using Extensible Markup Language (XML) as the basis for conformant metadata exchange; a corresponding XML Schema Document (XSD) specification enables validation of XML instance documents.

Primary components of this SIG are:

- Section 4, which describes the key properties, characteristics, content, and structure of gridded (raster) elevation data products within the NSG.
- Section 5, which defines the associated metadata, file format, and data storage for point clouds required to support NSG and Allied System for Geospatial Intelligence (ASG) interoperability.
- Section 6, which specifies both the required and recommended metadata content for elevation and point cloud data within the NSG.
- Annex B, Annex C, Annex D, and Annex E, which collectively specify the NEMIS logical model and its relationship to the NEMIS XSD-based metadata schema specification.
- Annex F, which identifies the NMF minimum mandatory metadata elements for data resource identification and their relative location within the NEMIS metadata schema.
- Annex G, which specifies how the NEMIS XSD-based metadata schema specification is structured, describes how NEMIS metadata exchange conformance is determined, and presents encoding guidelines for use in preparing valid NEMIS XML instance documents.

This SIG can be used in conjunction with the NEMIS XSD-based specification to create and validate geospatial metadata for gridded elevation and point cloud data that complies with NSG requirements. The NEMIS is intended for use by a wide variety of NGA users, NSG partners, and customers external to the NSG, to discover, access and exploit standardized elevation and point cloud data products.

2 References

The documents listed below provide context for the interpretation and application of this guidance. For dated references, only the cited edition or version applies. Additional informative references are cited in the Bibliography.

Table 2-1. Elevation and Point Cloud Data References

Standard or Specification
DGIWG – 250: Defense Gridded Elevation Data (DGED) Product Implementation Profile (STD-DP-15-025r2), Edition 1.2 (3 May 2018): https://portal.dgiwg.org/files/?artifact_id=68674
MIL-PRF-89020A, Performance Specification: Digital Terrain Elevation Data (DTED) (19 April 1996): https://earth-info.nga.mil/publications/specs/printed/89020A/89020A_DTED.pdf
MIL-STD-2401, DoD World Geodetic System (WGS), 11 (January 1994): https://nsgreg.nga.mil/doc/view?i=2058
MIL-STD-600001, Department of Defense Standard Practice: Mapping, Charting and Geodesy Accuracy (26 February 1990): https://earth-info.nga.mil/publications/specs/printed/600001/600001_Accuracy.pdf
NGA.SIG.0007_1.0_EGM2008, Information Guidance for Earth Gravitational Model 2008 (EGM2008), Version 1.0 (28 March 2012): https://nsgreg.nga.mil/doc/view?i=2316
NGA.SIG.0020_1.1_BPF, Binary Point File 3 (BPF3), BPF Public File Format Definition, Implementation Guide, Version 1.1 (29 December 2015): https://nsgreg.nga.mil/doc/view?i=4220
NGA.SIG.0025_1.0_EGM, Earth Gravitational Model and Geoid Heights, Version 1.0 (1 March 2019): https://nsgreg.nga.mil/doc/view?i=4752
NGA.SIG.0026.02_1.0_ACCGLOS, Accuracy and Predicted Accuracy in the NSG: Glossary of Terms; Technical Guidance Document (TGD) 1g, Version 1.0 (17 November 2016): https://nsgreg.nga.mil/doc/view?i=4454
NGA.STND.0036_1.0.0_WGS84, Department of Defense (DoD) World Geodetic System (WGS) 1984 - Its Definition and Relationships with Local Geodetic Systems, Version 1.0.0 (8 July 8 2014): https://earth-info.nga.mil/GandG/publications/NGA_STND_0036_1_0_0_WGS84/NGA.STND.0036_1.0.0_WGS84.pdf
NGA.STND.0037_2.0.0_GRIDS, Universal Grids and Grid Reference Systems, Version 2.0.0 (28 February 2014): https://earth-info.nga.mil/GandG/publications/NGA_STND_0037_2_0_0_GRIDS/NGA.STND.0037_2.0.0_GRIDS.pdf
NGA.STND.0046_1.0_GPM, The Generic Point-cloud Model (GPM): Implementation and Exploitation, Version 1.0 (10 March 2015): https://nsgreg.nga.mil/doc/view?i=4197

Table 2-2. Metadata References

Standard or Specification
ISO 19115-1:2014, Geographic information – Metadata – Part 1: Fundamentals: https://www.iso.org/standard/53798.html
ISO 19115-2:2019, Geographic information – Metadata – Part 2: Extensions for acquisition and processing: https://www.iso.org/standard/67039.html
ISO 19115-3:2016, Geographic information – Metadata – Part 3: XML schema implementation for fundamental concepts: https://www.iso.org/standard/32579.html
ISO 19157:2013, Geographic information – Data quality: https://www.iso.org/standard/32575.html
ISO/IEC 19505:2012, Information technology – Object Management Group Unified Modeling Language (OMG UML): Infrastructure: https://www.iso.org/standard/32624.html
ISO/IEC 19757:2016, Information technology – Document Schema Definition Languages (DSDL) – Part 3: Rule-based validation – Schematron: http://standards.iso.org/ittf/PubliclyAvailableStandards/c055982_ISO_IEC_19757-3_2016.zip
OGC 07-036r1, OpenGIS Geography Markup Language (GML) Encoding Standard, Version 3.2.1 (27 August 2007): https://portal.opengeospatial.org/files/?artifact_id=20509
OGC 08-094r1, SWE Common Data Modeling Encoding Standard, Version 2.0.0 (4 January 2011): https://www.opengeospatial.org/standards/swecommon
W3C XML Schema Part 1: Structures (Second Edition), 28 October 2004: http://www.w3.org/TR/2004/REC-xmlschema-1-20041028/
W3C XML Schema Part 2: Datatypes (Second Edition), 28 October 2004: http://www.w3.org/TR/2004/REC-xmlschema-2-20041028/
NGA.STND.0012_3.0_NMF – National System for Geospatial Intelligence (NSG) Metadata Foundation (NMF), Version 3.0 (31 August 2016): https://nsgreg.nga.mil/doc/view?i=4252
NGA.STND.0018_3.0_NMIS, National System for Geospatial Intelligence (NSG) Metadata Implementation Specification (NMIS): XML Exchange Schema, Version 3.0 (20 January 2017): https://nsgreg.nga.mil/doc/view?i=4268
NGA.STND.0022_8.0_NAS, NSG Application Schema (NAS) Part 1: Platform Independent Model – XML Schema, Version 8.0 (28 July 2016): https://nsgreg.nga.mil/doc/view?i=81111

Standard or Specification
NSG Application Schema (NAS) Documents, Base 19-Mar (26 March 2019): https://nsgreg.nga.mil/doc/view?i=4827
DES.ISM.XML.V13, Intelligence Community Technical Specification: XML Data Encoding Specification for Information Security Markings, Version 13 (9 May 2014): https://www.dni.gov/files/documents/CIO/ICEA/Juliet/ISM-Public.zip
DES.NTK.XML.V10, Intelligence Community Technical Specification: XML Data Encoding Specification for Need-To-Know Metadata, Version 10 (6 September 2013): https://www.dni.gov/files/documents/CIO/ICEA/India/NTK-V10-Public.zip
DES.RevRecall.XML.V1, Intelligence Community Technical Specification: XML Data Encoding Specification for Revision Recall, Version 1 (9 May 2014): https://www.dni.gov/files/documents/CIO/ICEA/Juliet/RevRecall-Public.zip

3 Terms, Definitions and Acronyms

3.1 Terms and Definitions

Important terms used within this document carry the meanings expressed in the following table.

Table 3-1. Terms and definitions

Term	Definition
absolute horizontal accuracy	The range of values for the error in an object's horizontal metric geolocation value with respect to a specified geodetic horizontal reference datum, expressed as a radial or circular error (CE) at the 90% probability level. There are two types of absolute horizontal accuracy: predicted absolute horizontal accuracy, which is based on error propagation via a statistical error model; and measured absolute horizontal accuracy, which is an empirically derived metric based on sample statistics. The term "horizontal accuracy" is assumed to correspond to "absolute horizontal accuracy." The 90% probability level (CE90) is the default; 95% and 50% probability levels (CE95 and CE50, respectively) may also be used. [NGA.SIG.0026.02_1.0_ACCGLOS]
absolute vertical accuracy	The range of values for the error in an object's metric elevation value with respect to a vertical reference datum, expressed as a linear error (LE) at the 90% probability level. There are two types of absolute vertical accuracy: predicted absolute vertical accuracy, which is based on error propagation via a statistical error model; and measured absolute vertical accuracy, which is an empirically derived metric based on sample statistics. The term "vertical accuracy" is assumed to correspond to "absolute vertical accuracy." The 90% probability level (LE90) is the default; 95% and 50% probability levels (LE95 and LE50, respectively) may also be used. [NGA.SIG.0026.02_1.0_ACCGLOS]
accuracy	The range of values for the error in an object's metric value with respect to an accepted reference value expressed as a probability. Statements of accuracy may be developed through applications of predictive statistics or by sample statistics based on multiple independent samples of errors. [NGA.SIG.0026_1.0_ACCGLOS]
arc second	A unit of angular measure equal to 1/60 of an arc minute, or 1/3600 of an arc degree.
bare earth	Terrain matrix representing the Earth's surface where cultural features and vegetation are not portrayed, but man-made earthen features such as levees, earthen bunkers and berms are portrayed. See Digital Terrain Model (DTM) definition.
baseline content	An elevation product that is created to an accepted NGA standard, specification, or Product Specific Guidance to support the wide range of customer requirements, *i.e.* DTED, HRTE3, and HRTE4.
bathymetry	The scientific study of underwater depths of lake and ocean floors; the underwater equivalent to hypsometry or topography.
bias error	A category of error; an error that does not vary from one realization (trial or experimental outcome) to the other. When error is represented as a random variable, random vector, stochastic process, or random field, a bias error corresponds to a non-zero mean value. [NGA.SIG.0026_1.0_ACCGLOS]
bundled file	A mechanism within the Binary Point Format (BPF) file structure to store additional data and metadata not typically associated with BPF files within the BPF file format. Bundled files consist of a standardized header providing the name of the bundled file and the length of the bundled data in bytes. The header is followed immediately by the bundled file data.
cell	A geographic 1-degree rectangle, also known as a GeoCell. A rectangular array of points on the reference grid registered to the reference grid origin and defined by a width and height of one degree of geodetic longitude and geodetic latitude.
circular error	An unsigned value that corresponds to the radius of a circle such that there is a 90% probability that the horizontal error resides within the circle; or equivalently, if the circle is centered at the target solution, there is a 90% probability that the true target horizontal location resides within the circle. CE90 corresponds to CE at the 90% probability level. [NGA.SIG.0026_1.0_ACCGLOS]
compliance	The state of a specific software product which implements a standard and has passed compliance testing against that standard. [Open Geospatial Consortium 08-134r6]
compression	A process by which the size of a file is reduced. Compression can be lossless, which preserves data quality, or lossy, which sacrifices some data quality for the sake of greatly reduced file size. Examples include MrSID and JPEG2000.
conceptual model	Model that defines the concepts of a universe of discourse. [ISO 19101]
conceptual schema	Formal description of a conceptual model. [ISO 19101]

Term	Definition
conformance	Fulfilment of specific requirements. [ISO 19105] NOTE For the NMF, the concept of conformance pertains to the conformance of specifications, including any profile or functional standard, with the series of ISO geographic information standards as a whole, plus NMF-authorized extensions and restrictions to those geographic information standards.
coordinate reference system	Coordinate system that is related to an object by a datum. [ISO 19111] NOTE 1 A coordinate system is a set of mathematical rules for specifying how coordinates are to be assigned to points. [ISO 19111] NOTE 2 A datum is a parameter or set of parameters that define the position of the origin, the scale, and the orientation of a coordinate system. [ISO 19111] NOTE 3 A coordinate is one of a sequence of *n* numbers designating the position of a point in *n*-dimensional space. [ISO 19111]
correlation	A technique to match the similarity of pixels in one digital image with comparable pixels in one or more other images. If matched to more than one image, it is multi-correlation. This technique supports various operations such as image to image registration and automated elevation data generation.
custom content	Elevation data that does not conform to an NGA product baseline but does conform to NGA's custom elevation data specification (this document).
data type	Specification of a value domain with operations allowed on values in this domain. Examples include Integer, Real, Boolean, CharacterString, and Date. [ISO 19103] NOTE Data types include primitive predefined types and user-definable types.
dataset	Identifiable collection of data that can be represented in an exchange format or stored on a storage media. [ISO 19115] NOTE A dataset may be a smaller grouping of data, which though limited by some constraint such as spatial extent or feature type, is located physically within a larger dataset. Theoretically, a dataset may be as small as a single feature or feature attribute contained within a larger dataset. A hardcopy map or chart may be considered a dataset.
datum	A coordinate system used to locate places on Earth. A geodetic datum is uniquely defined by five quantities: latitude, longitude, and geoid height are defined at the datum origin. The other two quantities defining the datum are the semimajor axis and flattening or the semimajor axis or the semiminor axis of the reference ellipsoid. [MIL-STD-600001]
digital elevation model (DEM)	A digital cartographic gridded representation of the elevation of the Earth's surface at regularly space intervals in *x* and *y* directions, using *z*-values referenced to a common vertical datum. See also DSM and DTM.
digital surface model (DSM)	A DEM of the earth's reflective surface that depicts the elevation of the top of buildings, trees, towers, and other features elevated above the bare earth.
digital terrain model (DTM)	A DEM representing the bare earth terrain. See bare earth definition.
edge matching	A process by which cells share a common row of terrain posts on all sides with contiguous cells. The common row must be identical to its adjacent cell.
elevation	Vertical distance above a datum, usually mean sea level, to a point or object on the Earth's surface; not to be confused with altitude, which refers to points or objects above the Earth's surface. In geodetic formulas, elevations are heights: *h* is the height above the ellipsoid; *H* is the height above the geoid or local datum. Occasionally *h* and *H* may be reversed. [NGA.SIG.0026_1.0_ACCGLOS]
ellipsoid	A mathematical model of the size and shape of the earth, formed by rotating an ellipse about its minor axis.
ellipsoidal height (*h*)	Distance of a point from the ellipsoid surface measured upward along a line perpendicular to the ellipsoid, positive if upwards or outside of the ellipsoid. Also known as geodetic height. NOTE Only used as part of a three-dimensional coordinate and never on its own.
Generic Point-cloud Model (GPM)	A sensor model developed by the Community Sensor Model Working Group (CSMWG) that stores and exploits error covariance information for point cloud datasets, applies to point clouds from multiple modalities, and provides for error propagation and rigorous data adjustment. [NGA.STND.0046_1.0_GPM]
geoid	The equipotential surface of the Earth's gravity field which best fits, in a least squares sense, global mean sea level. Its smooth but irregular surface results from the uneven distribution of mass within and on the surface of Earth.
geoid height (*N*)	Distance of a point on the geoid from the ellipsoid surface measured upward along the line perpendicular to the ellipsoid, positive if above the ellipsoid. [ISO 19111] NOTE The reference surface is based on the geoid and may be approximated by an ellipsoid or hydrographic surface. Height is distinguished from elevation in that it is a directional measurement. A height below the reference surface will have a negative value. Negative height is also called depth. This definition also applies to altitude.

Term	Definition
gravity-related height (*H*)	Height above the geoid or local datum. NOTE In particular, orthometric height or normal height, which are both approximations of the distance of a point above the mean sea level.
gridded data	A geographic data model representing information as a regularly spaced array of points arranged in a row and column format. The intersection of each row and column is referenced by its geographic *x*,*y* location.
ground control point	Fixed, surveyed location on the ground. Treated as truth points for reference. Sometimes referred to as fiducials.
ground sample distance	Distance between two adjacent posts in an elevation grid. Equivalent to post spacing. NOTE For grids in geographic projection, the ground sample distance is defined in arc seconds of latitude.
height	Distance of a point from a chosen reference surface measured upward along a line perpendicular to that surface. [DGIWG – 116-1] NOTE A height below the reference surface will have a negative value.
hypsography	The scientific study of the Earth's topologic features above sea level, especially the measurement and mapping of land elevations.
intensity	A generic signal strength that is typically used to modulate to brightness of a pixel or point in a display system.
interpolation	As it relates to elevation data, it is the estimation of *z*-values at a point with *x*,*y* coordinates, based on the known *z* values of surrounding points.
level (grid)	A categorization of elevation data by level of detail, defined by ground sample distance. Levels range from 0 to 9. [DGWIG 250]
level (point cloud)	The point cloud processing level: Level 0 (raw sensor data), Level 1 (initially processed point cloud data), Level 2 (intermediate point cloud data), Level 3 (exploitable point cloud), and Level 4 (derived products). The point cloud levels defined here are based on the definitions in NGA.SIG.0004_1.1 and were originally developed as part of a LiDAR metadata Technical Exchange Meeting (TEM) between DoD, IC, and industry partners in July 2008. The definitions in this SIG have been modified to make them more generic and sensor-agnostic.
linear error	An unsigned value that corresponds to the length of a vertical line such that there is a 90% probability that the absolute value of vertical error resides along the line. If the line is doubled in length and centered at the target solution, there is a 90% probability that the true target vertical location resides along the line. LE90 corresponds to LE at the 90% probability level. [NGA.SIG.0026_1.0_ACCGLOS]
map projection	An orderly system for portraying the meridians and parallels of the reference ellipsoid upon a geometric plane, called the map projection plane.
metadata	Information about the content, quality, condition, and other characteristics of data. [ISO 19115-1]
metadata element	Discrete unit of metadata. [ISO 19115-1] NOTE 1 Metadata elements are unique within a metadata entity. NOTE 2 Equivalent to an attribute in UML terminology.
metadata entity	Set of metadata elements describing the same aspect of data. [ISO 19115-1] NOTE 1 May contain one or more metadata entities. NOTE 2 Equivalent to a class in UML terminology.
metadata schema	A logical plan showing the relationship between different metadata entities and elements, normally through establishing rules for the use and management of metadata, specifically as regards the semantics, the syntax, and the multiplicity (obligation level) of values. Also referred to as an element set.
metadata section	Subset of metadata which consists of a collection of related metadata entities and metadata elements. [ISO 19115-1] NOTE Equivalent to a package in UML terminology.
modality	A specific remote sensing technology that measures a specific set of phenomenologies, and hopefully standardized to consistent units. Examples include panchromatic imagery, HSI, LiDAR (linear mode, Geiger mode, etc.), RADAR, and OPIR.
octree	A 3D tree data structure in which each internal cell has exactly eight children. Octrees are the 3D analog of quadtrees and are used to partition a 3D volume by recursively partitioning it into eight spaces.
phenomenology	A specific physical characteristic that can be measured through an energy source (*e.g.*, emittance) or interaction (*e.g.*, reflectance).
pixel	The basic data unit of a raster image. In terrain elevation datasets, a pixel is equivalent to an elevation post.
point	An individual coordinate in 3D space.

Term	Definition
point cloud	A collection of data points in 3D space. The distance between points is generally non-uniform and hence all three coordinates (Cartesian or spherical) for each point must be specifically encoded.
point density	The average number of point cloud measurements (XYZ tuples) per area at which the surface of the earth is sampled. Commonly the point density is given for one square meter and therefore is measured in points per square meter.
post	Location of the intersections of rows and columns within an elevation grid. Post spacing for a rectified grid is a measure of its horizontal resolution. [DGIWG – 116-1: MIL-PRF-89020A]
post spacing	Horizontal spacing between adjacent posts along the *x* or *y* axis in an elevation grid, equivalent to ground sample distance.
predicted accuracy	The range of values for the error in a specific object's metric value expressed as a probability derived from an underlying and accompanying detailed statistical error model. [NGA.SIG.0026_1.0_ACCGLOS] NOTE 1 If the statistical error model does not include the identification of a specific probability distribution, a gaussian (or normal) probability distribution is typically assumed in order to generate probabilities. NOTE 2 The term "predicted" in predicted accuracy corresponds to the use of predictive statistics in the detailed statistical error model; it does not correspond to a prediction of accuracy applicable to the future since the corresponding error corresponds to a geolocation already extracted.
quadtree	A 2D tree data structure in which each internal cell has exactly four children. Quadtrees are the 2D analog of octrees and are commonly used to partition a 2D space by recursively partitioning it into four quadrants or regions.
quarter cell	Geographic 30-minute by 30-minute rectangle. Rectangular array of points on the reference grid registered to the reference grid lower left origin. All quarter cells start at full degree or half degree locations, *i.e.* XX:00:00 or XX:30:00.
random error	A non-deterministic category of error; a measure of deviation from an ideal or true value which results from an accidental and unknown combination of causes and varies from one measurement to the next. For NSG applications, a random error is typically represented as a random variable, random vector, stationary process, or random field. [NGA.SIG.0026_1.0_ACCGLOS]
raster	A raster consists of a rectangular matrix of cells (or pixels) organized into rows and columns where each cell contains a value representing information, such as elevation.
reflective surface	The elevation model which includes man-made features and vegetation.
relative horizontal accuracy	The range of values for the error in the difference between two objects' horizontal metric geolocation values with respect to a specified geodetic horizontal reference datum; *e.g.* expressed as a radial or circular error at the 90 percent probability level (CE90). There are two types of relative horizontal accuracy: predicted relative horizontal accuracy, which is based on error propagation via a statistical error model; and measured relative horizontal accuracy, which is an empirically derived metric based on sample statistics. [NGA.SIG.0026_1.0_ACCGLOS]
relative vertical accuracy	The range of values for the error in the difference between two objects' vertical metric geolocation values with respect to a specified geodetic vertical reference datum; *e.g.* expressed as a linear error at the 90 percent probability level (LE90). There are two types of relative vertical accuracy: predicted relative vertical accuracy, which is based on error propagation via a statistical error model; and measured relative vertical accuracy, which is an empirically derived metric based on sample statistics. [NGA.SIG.0026_1.0_ACCGLOS]
resampling	A spatial transformation of raster data involving interpolation of individual posts within the grid. Examples of resampling algorithms include nearest neighbor, bilinear, and cubic convolution.
resolution	Distance between adjacent posts in a grid. Equivalent to ground sample distance (GSD) or post spacing. Resolution ranges are as follows: Low: 30 meters or greater Medium: greater than 5 meters and less than 30 meters High: 5 meters or less
resource	Identifiable asset or means that fulfils a requirement. [ISO 19115-1]
sensor model	A mathematical description of the relationship between the 3D object space and the associated sensing system.
spherical accuracy	An unsigned value that corresponds to the radius of a sphere such that there is a 90% probability that the 3D error resides within it. [NGA.SIG.0026_1.0_ACCGLOS]
synthetic point	Any point not derived from the input Level 0 data in point cloud datasets. Examples include void fill and interpolated points. The synthetic points should be flagged using the classification bit flag as defined in the version of LAS and the point record type being used.

Term	Definition
systematic error	An error with a nonzero mean, the effect of which is not reduced when the observations are averaged. Systematic error (or systematic bias) is usually an error characteristic or error effect due to errors that are represented by random variables, random vectors, stochastic processes, or random fields. For example, an effect on observations (samples) such that their pattern of magnitude and direction are consistent but not necessarily constant. [NGA.SIG.0026_1.0_ACCGLOS]
tile	In gridded data, this is a rectangular array of points on the reference grid, registered with and offset from the reference grid origin and defined by a width and height. [ISO/IEC 15444-1]
Universal Polar Stereographic (UPS)	A grid system based on the polar stereographic projection, applied to the Earth's polar regions north of 84° N and south of 80° S. The central point is either the North Pole or the South Pole.
Universal Transverse Mercator (UTM)	A specialized application of the transverse Mercator projection. The globe is divided into 60 north and south zones, each spanning 6° of longitude. Each zone has its own central meridian. Zones 1N and 1S start at 180° W. The limits of each zone are 84° N and 80° S, with the division between north and south zones occurring at the equator. The origin for each zone is its central meridian and the equator. To eliminate negative coordinates, the coordinate system alters the coordinate values at the origin. The value given to the central meridian is the false easting, and the value assigned to the equator is the false northing. A false easting of 500,000 meters is applied. A north zone has a false northing of zero, while a south zone has a false northing of 10,000,000 meters.
variable length record (VLR)	A VLR is specific to LAS file formats and contains variable types of data including projection information, metadata, waveform packet information, and user application data.
void	Portion of a gridded elevation dataset where no elevation data are available. Each elevation post located within a void area is assigned a discrete, no-data value. The default no-data value is often -32767 in 16-bit integer GeoTIFF files, but may vary by file encoding and dataset.
XML namespace	A collection of names, identified by a URI reference, which are used in XML documents as element types and attribute names.

3.2 Acronyms

The acronyms that are used in this document are specified in the following table.

Table 3-2. Acronyms

Acronym	Definition
AOI	Area of Interest
API	Application Programming Interface
ASG	Allied System for Geospatial Intelligence
ASPRS	American Society of Photogrammetry and Remote Sensing
BPF	Binary Point Format
CAPCO	Controlled Access Program Coordinating Office (CIA)
CE90	Circular (Horizontal) Error measured at 90% probability
COTS	Commercial Off-the-Shelf
CRS	Coordinate Reference System
DEM	Digital Elevation Model
DGED	Defense Gridded Elevation Data
DGIWG	Defence Geospatial Information Working Group
DISR	Defense Information Standards Registry

Acronym	Definition
DMF	DGIWG Metadata Foundation
DSM	Digital Surface Model
DTED	Digital Terrain Elevation Data
DTM	Digital Terrain Model
EGM	Earth Gravitational Model
EGM2008	Earth Gravitational Model of 2008
EGM2020	Earth Gravitational Model of 2020
ENVI	Environment for Visualizing Images (geospatial software by Harris)
EO	Electro-Optical
EPSG	European Petroleum Survey Group
EPT	Entwine Point Tile
ESM	Elevation Surface Model
EVLR	Extended Variable Length Record
FMV	Full Motion Video
GEOINT	Geospatial Intelligence
GeoTIFF	Geographic Tagged Image File Format
GML	Geography Markup Language
GOTS	Government Off-The-Shelf
GPM	Generic Point Cloud Model
GPS	Global Positioning System
GRiD	Geospatial Repository and Data Management System
GSD	Ground Sample Distance
GWG	GEOINT Standards Working Group
HaE	Height Above the Ellipsoid
HDF	Hierarchical Data Format
HRE	High Resolution Elevation (NGA.IP.0002_1.1)
HRTE3	High Resolution Terrain, Level 3 (0.4 arc seconds)
HRTE4	High Resolution Terrain, Level 4 (3 meters)
IFOV	Instantaneous Field of View
IFSAR	Interferometric Synthetic Aperture RADAR
IOGP	International Association of Oil and Gas Producers
ISO	International Organization for Standardization
JITC	Joint Interoperability Test Command
LAS	LASer (LiDAR) file format
LAZ	LAser file format Zipped
LE90	Linear (Vertical) Error measured at 90% probability
LiDAR	Light Detection and Ranging
LZW	Lempel-Ziv-Welch compression algorithm
MIPC	Modality Independent Point Cloud
MSL	Mean Sea Level
NATO	North Atlantic Treaty Organization
NIIRS	National Imagery Interpretability Rating Scale
NITF	National Imagery Transmission Format
NMF	NSG Metadata Foundation
NSG	National System for Geospatial Intelligence
ODS	Open Data Store
OGC	Open Geospatial Consortium
PDAL	Point Data Abstraction Library
POC	Point Of Contact
PSVI	Post Schema Validation Infoset
RII	Relative Intensity Image
Rx	Receiver
S3	Simple Storage Service
SAR	Synthetic Aperture Radar

Acronym	Definition
SE90	Spherical Error measured at 90% probability
SfM	Structure from Motion
SIPC	Sensor Independent Point Cloud
SRT1F	Shuttle Radar Topology, Level 1 (100 m), Filled
SRT2F	Shuttle Radar Topology, Level 2 (30 m), Filled
SRTM	Satellite Radar Topography Mission
TDA	Tactical Decision Aid
TDF	TREx DEM Finished
TDR	TREx DEM Raw
TDT	TREx DEM Temporary
TIFF	Tagged Image File Format
TREx	TanDEM-X High Resolution Elevation Data Exchange
Tx	Transmitter
UoM	Unit of Measure
UPS	Universal Polar Stereographic
USGS	United States Geological Survey
UTC	Universal Time Coordinated
UTM	Universal Transverse Mercator
W3C	World Wide Web Consortium
WKT	Well-Known Text
WGS 84	World Geodetic System 1984
XDM	XPath Data Model
XML	eXtensible Markup Language
XSD	XML Schema Definition
XSLT	eXtensible Stylesheet Language Transformations

4 Gridded Elevation Data

4.1 Introduction

This section describes the key properties, characteristics, content, and structure of gridded (raster) elevation data products within the National System for Geospatial Intelligence (NSG). The gridded elevation specification in this Standardization Implementation Guidance (SIG) closely aligns with the Defense Gridded Elevation Data (DGED) implementation profile of the Defence Geospatial Information Working Group (DGIWG) (DGIWG – 250). In doing so, it adopts the DGED resolution levels for the creation of custom gridded elevation datasets.

The intent of this section is to increase interoperability between organizations producing and using gridded elevation data. The rapid increase of elevation data sources, from fortuitous stereo satellite imagery to LiDAR to interferometric SAR, has made it necessary to standardize the format of high-resolution gridded elevation data, in order to ensure interoperability between datasets. This section does not prescribe methods for the creation or use of gridded elevation data, but describes a standardized data exchange format, file structure, tiling scheme, and metadata schema for its distribution within the NSG.

4.2 Data Content and Structure

4.2.1 Overview

The primary guidance for the gridded elevation data structure is the Defense Gridded Elevation Data (DGED) implementation profile produced by the Defence Geospatial Information Working Group (DGIWG). The DGED data structure is a uniform, orthogonal, grid-based geospatial elevation model that supports a wide range of geospatial resolutions, referred to as levels (see DGIWG – 250 for more details).

The DGED grid structure is represented by a collection of regularly or uniformly spaced points. Within a DGED dataset (or tile), only one spatial resolution can be represented. Because grids are raster files, the grid resolution is often referred to as the pixel size, which in terrain terms corresponds to the post spacing or ground sample distance (GSD). The GSD should be chosen to best capture the level of detail of the source dataset (*e.g.*, LiDAR point cloud, stereo imagery, etc.), as terrain features smaller than the GSD may not be represented. On the other hand, high-resolution, small-GSD grids are more expensive to process and may contain errors not characteristic of the actual terrain.

NGA defines two product types, based on their conformance to NGA standards:

1. **Baseline Elevation Products:** NGA-approved elevation content that is created in accordance with an existing NGA-sanctioned program, implementation specification, or product-specific guidance. Examples include DTED2, HRTE3, and TREx DEM Finished (TDF).
2. **Custom Elevation Products:** Elevation content that is not created in accordance with an existing NGA-sanctioned program, implementation specification, or product-specific guidance. Custom gridded elevation data should meet the standards of quality defined by those producing the data. However, for such custom elevation content to be ingested into the NSG, the data should meet the metadata and accuracy reporting guidelines defined in this SIG.

This SIG was produced, in part, to incorporate the DGED file structure, metadata and accuracy requirements into NSG elevation products, achieve compliance with the NSG Metadata Foundation (NMF) metadata standard, and create a naming and tiling scheme that is consistent for each DGED level across all Universal Transverse Mercator (UTM) and Universal Polar Stereographic (UPS) coordinate reference systems.

4.2.2 Elevation Domains

NGA organizes all gridded elevation content into three elevation domains based on the GSD of each DGED level. NGA has categorized the elevation domains based on latitudinal GSD in arc seconds and meters, corresponding to the DGED levels shown in Table 4-1. The three domains are low resolution, medium resolution, and high resolution. Each domain has specific requirements for coordinate system projection, accuracy, and tiling scheme. Some low- and medium-resolution products have global coverage, while high-resolution products typically have local or regional coverage, depending on the data source and intended use.

Table 4-1. DGED Multi-level geographic and UTM Grids

Elevation Domain	DGED Level	GSD[1]		Baseline Products
		arc seconds[2]	meters	
Low Resolution	0	30	*1,000*	DTED0
	1	3	*100*	DTED1, SRT1F
	2	1	*30*	DTED2, SRT2F
Medium Resolution	3	0.4	*12*	HRTE3, TDF
High Resolution	4b	*0.15*	5	
	4	*0.12*	4	
	5b[3]	*0.09*	3	HRTE4
	5	*0.06*	2	
	6	*0.03*	1	
	7	*0.015*	0.5	
	8	*0.0075*	0.25	
	9	*0.00375*	0.125	

Notes:
[1] Values in italics are approximate, and based on the DGED specification (DGIWG – 250 version 1.2).
[2] Geographic GSD represents arc seconds of latitude. See Table 4-2 for longitudinal GSD based on latitude zone.
[3] Not included in DGED.

4.2.3 Low-resolution Elevation Domain

Low-resolution elevation content has a GSD of 30 meters or greater. All data within this domain is projected to a geographic grid referenced to the WGS 84 ellipsoid, with GSD defined in units of arc seconds. This elevation content has been produced by NGA, or its predecessor organizations, for over 40 years. In that time, the data have been integrated into critical systems for navigation, mission planning, and environmental analysis. The most common format for low-resolution elevation content is currently Digital Terrain Elevation Data (DTED). The DTED specification (MIL-PRF-89020B) provides a technical description of the DTED file structure, product guidelines (including accuracy tolerances), terrain surface characteristics (including water body editing requirements), and requirements for physical media.

NGA no longer intends to produce new data in accordance with the DTED product specification. At a future date, NGA intends to retire the DTED product specification, at which time it will no longer recognize data created to that specification as meeting current standards. NGA understands that many of its customers rely on data in the DTED format and will continue to both maintain legacy content and make new DTED-formatted content available through its data distribution channels. DTED-formatted data may not meet all criteria under the DTED specification; however, it retains the DTED file structure, to include headers, metadata and file sizing requirements ensuring legacy system compatibility. Additionally, it is expected that given continuous advancements in collection methods, future sources will produce DTED-formatted data that exceeds the specified accuracy tolerances and provides greater fidelity.

NGA recommends that low-resolution data producers, users, and developers migrate to the DGED format, and follow the guidance within this SIG.

4.2.4 Medium-resolution Elevation Domain

Medium-resolution elevation content includes gridded products with a GSD between five and 30 meters. However, despite the wide range of medium-resolution values, only one DGED level (Level 3) occupies this domain. It serves as a transition between global low-resolution data, used for navigation and large-scale environmental analysis, and high-resolution elevation data, which has limited coverage but greater accuracy and versatility of use. DGED-compliant medium-resolution data shall be provided in geographic coordinates referenced to the WGS 84 ellipsoid, with a latitudinal GSD of 0.4 arc seconds (approximately 12 meters).

NGA distributes baseline High Resolution Terrain Level 3 (HRTE3) and TREx DEM Finished (TDF) products in the medium resolution domain. These products are typically used within the NSG for mission planning, mobility analysis, and disaster relief.

4.2.5 High-resolution Elevation Domain

High-resolution elevation content has a GSD of five meters or less. Products within this domain should be generally be projected to a Universal Transverse Mercator (UTM) or Universal Polar Stereographic (UPS) coordinate system referenced to the WGS 84 datum in meters, unless they are part of a tiled dataset spanning multiple UTM zones or geocells. In most cases, a UTM projection should be used between the latitudes of 84° N and 80° S and a UPS projection should be used north of 84° N and south of 80° S. NGA produces baseline HRTE4 products in the high-resolution domain. Analysts typically use high-resolution elevation content in scenarios where greater accuracy and precision are required, such as 3D modeling, localized mission planning, and the creation of tactical decision aids.

With the rapid growth in airborne light detection and ranging (LiDAR) collection and the development of EO-derived point clouds, high-resolution elevation source data is increasingly common in cities and other areas of commercial or defense interest. Where consecutive collects are available, change detection is possible. It is relatively easy to create digital surface models (DSMs) from processed point clouds, although the quality depends partly on the source density and interpolation techniques used to process the point cloud. Algorithms permit the creation of digital terrain models (DTMs) from DSMs and point clouds, with varying degrees of accuracy.

4.2.6 Horizontal Spatial Resolution

NGA recommends that custom elevation content in geographical coordinates adopt the varying longitudinal resolutions based upon latitude, as specified in DGED and outlined in Table 4-2. Due to the convergence of meridians at higher latitudes, the longitudinal arc second point spacing of geographic products varies as a function of latitude. As a result, the GSD of longitude (expressed in arc seconds) required to provide a similar post spacing (in linear units) to that obtained by a GSD in latitude increases toward the poles. In order to maintain a consistent relationship between the *x* and *y* dimensions, a scaling factor must be applied to the latitudinal spacing (d). The latitude range is independent of hemisphere, meaning that Zone 1 covers from 50°S to 50°N and the remaining zones are split into both hemispheres.

Table 4-2. Longitudinal post spacing based on latitude zone

Zone	Latitude Range (North and South)	Latitude Spacing	Longitude Spacing
1	0° - 50°	d	d
2	50° - 60°	d	$1.5d$
3	60° - 70°	d	$2d$
4	70° - 80°	d	$3d$
5	80° - 85°	d	$5d$
6	85° - 90°	d	$10d$

4.3 Accuracy

4.3.1 Overview

The principal horizontal and vertical accuracy measurements to be associated with gridded elevation data conforming to this SIG are listed in Table 4-3:

Table 4-3. Standard accuracy measurements for reporting

Error Term	Scalar Representation to be Reported	Unit
Absolute horizontal accuracy	Absolute Circular Error 90 ($CE90_{ABS}$)	meter
Absolute vertical accuracy	Absolute Linear Error 90 ($LE90_{ABS}$)	meter
Relative horizontal accuracy	Relative Circular Error 90 ($CE90_{REL}$)	meter
Relative vertical accuracy	Relative Linear Error 90 ($LE90_{REL}$)	meter

These terms are defined in Section 3.1 and are discussed in more detail in the Accuracy and Predicted Accuracy portion of the NSG: Glossary of Terms (NGA.SIG.0026.02_1.0_ACCGLOS). The accuracy measurements are expressed in NEMIS metadata files using the Quality Measures in the NSG Information Resource (IR) Registry described in Annex E.

In addition to these four terms, the SIG accuracy tables reference random horizontal and random vertical error per point, which are also defined in the cited reference.

4.3.2 Establishment of Accuracy Requirements

Many factors contribute to the absolute and relative accuracy of elevation data. Some of these are common to collection methodologies and others are unique to a collection methodology. For EO-derived DSMs, the accuracy of the exterior orientation solution, the quality of the camera calibration, the resolution of the input images, and the number of input images are all examples of contributors to data quality. For active systems like LiDAR, other factors such as relative pointing, platform orientation, calibration, and range resolution come into play. However, the accuracy of the absolute ground control or reference data used in data adjustment is a common error contributor across modalities. Although relative horizontal accuracy ($CE90_{REL}$) as a rule improves (becomes smaller) with decreasing GSD, absolute horizontal accuracy ($CE90_{ABS}$) is a function of both random error and systematic biases. Systematic biases, regardless of error source (*e.g.*, ground control errors, poor positioning, and orientation parameters) may result in larger absolute $CE90_{ABS}$ values. This section provides insight into how the accuracy values in this SIG were established.

Accuracy criteria in this SIG are based on criteria originally developed for the High Resolution Elevation (HRE) standard (NGA.IP.0002_1.1) and then carried into the DGIWG Elevation Surface Model (ESM) standard (DGIWG – 116-1). The absolute accuracy goals were established using engineering judgement and set to be consistent with other elevation standards. The required accuracy, both horizontal and vertical, improves with decreasing GSD. This is partly due to increased resolution providing finer detail and reducing the amount of interpolation between elevation posts. In addition, high-resolution gridded elevation datasets are commonly (though not always) derived from higher-quality sources, including LiDAR point clouds.

The relative accuracy standards were set to ensure that the data content would make sense. For example, the relative horizontal error was set such that it was less than half of a post spacing. This means that there is no uncertainty on whether adjacent posts are in fact in the correct order and adjacent to one another. It also ensures that their random error components do not intersect, leading to potential ambiguity. Random vertical error was set so that as the spatial density in the horizontal plane increased, the relative accuracy also improved. In other words, as horizontal resolution increases, vertical precision increases. This prevents a dataset that is densely sampled in the horizontal dimensions but extremely noisy in the vertical dimension. However, based on previous empirical testing and the fact that errors are often spatially and temporally correlated, it is expected that relative errors will grow as a function of

distance as correlation decreases. Thus, the SIG accuracy values allow for such growth but ensure the relative horizontal error at 90% Confidence Interval (C.I.) does not grow beyond one post spacing.

Relative accuracies were set (at a 90% C.I.) for points in a local neighborhood, to include adjacent points, as follows:

- Relative Horizontal Error 90 ($CE90_{REL,0}$) = 0.5*P, where P is the post spacing in meters
  Note: This quantity is labeled R_{h0} in Figure 4-1.
- Relative Vertical Error 90 ($LE90_{REL,0}$) = 0.25*P
  Note: the "0" in the subscript above is used to indicate that this is for points that are close together (adjacent).

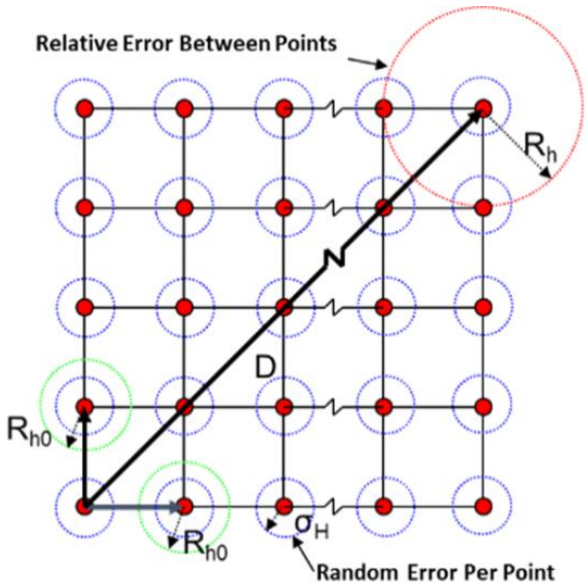

Figure 4-1. Relative accuracy growth as function of distance

Setting thresholds for relative accuracy also establishes the allowable random errors. This assumes that only random error is contributing to relative accuracy in a local region due to high correlation of other error sources. Making this assumption, the random error allowable per point is established as follows:

- Random Horizontal Error (1 sigma): $\sigma_H \leq \frac{0.5P}{2.146*\sqrt{2}}$
- Random Vertical Error (1 sigma): $\sigma_V \leq \frac{0.25P}{1.645*\sqrt{2}}$

Relative accuracy, as used by NGA, is a point-to-point metric and is always associated with two (or more) points and the uncertainty between those points. For some people, the term relative accuracy implies the noise or local error of a point in the dataset after systematic biases have been removed. However, this is more closely associated with the random error of a point and not the relative error between points. A vendor can often state (or propagate uncertainties to determine) the random error expected at a specific point, but usually does not directly consider point-to-point uncertainty as defined by NGA. So, random error bounds is a metric useful to the data provider. Figure 4-2 illustrates some of these concepts on relative error.

It should be noted that the random error values provided in the HRE standard (NGA.IP.0002_1.1), subsequent documents, and this SIG were scaled back up from the results obtained with the equations above to provide the random error at the 90% C.I. The accuracy tables include the 90% C. I. values.

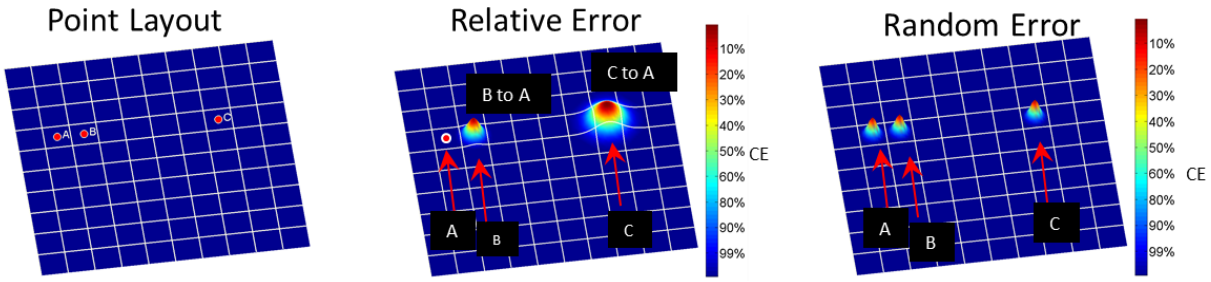

Figure 4-2. Relative and random error

Many error contributors in a local region are highly correlated, leading to random error being the primary contributor to relative error in a local region. However, as the distance (d) between points increases, correlation between other error sources often decreases, leading to an increase in relative accuracy as shown above until some maximum relative accuracy ($CE90_{REL,max}$, $LE90_{REL,max}$) is reached when the correlations go to zero. This growth is typically a function of distance, but this is a generalization since there are many ways to capture and process elevation data, each with its own unique characteristics. For one potential method to model such correlations, the reader is referred to the Generic Point Cloud Model (GPM) documentation (NGA.STND.0046_1.0_GPM) and its use of functions to represent correlation characteristics. However, due to the complexities and variations in correlation between collection methodologies and datasets, no specifics of correlation decay were set in HRE or this SIG. Instead, two bounds were set. The first was relative accuracy in the local area ($CE90_{REL,0}$, $LE90_{REL,0}$) where points are near each other and the only contribution is random error. The second was the maximum value of relative error ($CE90_{REL,max}$, $LE90_{REL,max}$) allowed between any two points in a single product. The maximum values were set to be:

- Relative Horizontal 90 ($CE90_{REL,max}$) = P, where P is the post spacing
  Note: this quantity is labeled R_h in Figure 4-1.
- Relative Vertical 90 ($LE90_{REL,max}$) = 0.5*P

The methods described above were used to develop the following parameters:

- Maximum horizontal random error per point ($\sigma_{H,90}$)
- Maximum vertical random error per point ($\sigma_{V,90}$)
- Absolute Horizontal Accuracy ($CE90_{ABS}$) – goal, not threshold
- Absolute Vertical Accuracy ($LE90_{ABS}$) – goal, not threshold
- Relative Horizontal Accuracy threshold ($CE90_{REL,0}$) for a pair of localized (nearly adjacent) points
- Relative Vertical Accuracy threshold ($LE90_{REL,0}$) for a pair of localized (nearly adjacent) points
- Relative Horizontal Accuracy threshold ($CE90_{REL,max}$) between any two points in the dataset
- Relative Vertical Accuracy threshold ($LE90_{REL,max}$) between any two points in the dataset

These parameters are the basis for the DGED accuracy requirements and are provided by DGED level in Table 4-4 and Table 4-5. The absolute accuracy requirements ($CE90_{ABS}$, $LE90_{ABS}$) for the highest resolution data (DGED Levels 5-9) are difficult to obtain and require precise adjustment to high-quality

ground control points. For this reason, the absolute CE90 and LE90 values for each level is a goal, not a requirement. The listed values may be beyond current capabilities, particularly for EO-derived elevation datasets that lack ground control points. Although the absolute accuracy ($CE90_{ABS}$, $LE90_{ABS}$) is not required to meet a threshold, the estimated absolute accuracy values shall be reported in the metadata.

4.3.3 Horizontal Accuracy

The DGED horizontal accuracy requirements are listed in Table 4-4.

Table 4-4. Horizontal accuracy requirements

DGED Level	GSD[1]		Random Horizontal Error Per Point, $\sigma_{H,90}$ (m)[4]	Relative Horizontal Accuracy, $CE90_{REL,0}$ (m)[4]	Relative Horizontal Accuracy, $CE90_{REL,max}$ (m)[4]	Goal: Absolute Horizontal Accuracy, $CE90_{ABS}$ (m)[5]
	angular (arc-sec)[2]	linear (m)				
0	30	*1,000*				50
1	3	*100*				50
2	1	*30*				23
3	0.4	*12*	4.40	6.22	12.40	15.00
4b	*0.15*	5	1.75	2.50	5.00	6.00
4	*0.12*	4	1.41	2.00	4.00	5.00
5b[3]	*0.09*	3	1.08	1.50	3.00	4.00
5	*0.06*	2	0.71	1.00	2.00	3.00
6	*0.03*	1	0.35	0.50	1.00	2.00
7	*0.015*	0.5	0.18	0.25	0.50	1.00
8	*0.0075*	0.25	0.09	0.12	0.25	0.50
9	*0.00375*	0.125	0.04	0.06	0.125	0.25

Notes:

1 Values in italics are approximate.

2 Geographic GSD represents arc seconds of latitude. Due to the convergence of meridians toward the poles, the GSD of longitude (expressed in arc seconds) required to provide a similar post spacing (in linear units) to that obtained by a GSD in latitude increases toward the poles. Refer to Table 4-2 for the longitudinal GSD based on latitude zone.

3 Not included in DGED (DGIWG – 250 Edition 1.2).

4 The Relative Horizontal Accuracy ($CE90_{REL}$) and Random Horizontal Accuracy (σ_H) values may be difficult to assess in low-resolution datasets. In these datasets, very large targets (which may not be available) would be required for such assessment. Although low-resolution data do not have stated relative horizontal accuracy requirements, acceptable results can be obtained by down sampling higher-resolution elevation data with known horizontal accuracy values.

5 Absolute Horizontal Accuracy ($CE90_{ABS}$) values for each level are goals (not threshold requirements) but the estimated value should be reported in the metadata.

4.3.4 Vertical Accuracy

The DGED vertical accuracy requirements are listed in Table 4-5.

Table 4-5. Vertical accuracy requirements

DGED Level	GSD[1]		Random Vertical Error Per Point, $\sigma_{V,90}$ (m)	Relative Vertical Accuracy, $LE90_{REL,0}$ (m)[4]	Relative Vertical Accuracy, $LE90_{REL,max}$ (m)[4]	Goal: Absolute Vertical Accuracy, $LE90_{ABS}$ (m)[5]
	angular (arc-sec)[2]	linear (m)				
0	30	*1,000*			20	30
1	3	*100*			20	30
2	1	*30*			12	18
3	0.4	*12*	2.20	3.00	6.20	12.40
4b	*0.15*	5	0.87	1.25	2.50	5.00
4	*0.12*	4	0.71	1.00	2.00	4.00
5b[3]	*0.09*	3	0.54	0.75	1.50	3.00
5	*0.06*	2	0.35	0.50	1.00	2.00
6	*0.03*	1	0.18	0.25	0.50	1.00
7	*0.015*	0.5	0.09	0.125	0.25	0.50
8	*0.0075*	0.25	0.04	0.062	0.12	0.25
9	*0.00375*	0.125	0.02	0.031	0.06	0.12

Notes:

1 Values in italics are approximate.

2 Geographic GSD represents arc seconds of latitude. Due to the convergence of meridians toward the poles, the GSD of longitude (expressed in arc seconds) required to provide a similar post spacing (in linear units) to that obtained by a GSD in latitude increases toward the poles. Refer to Table 4-2 for the longitudinal GSD based on latitude zone.

3 Not included in DGED (DGIWG – 250 Edition 1.2).

4 The vertical accuracy requirements in Table 4-5 are based on low- to medium-relief areas (majority of non-hydrological surface consists of slope less than 20 percent) within the data cell. In areas where the majority of non-hydrological surface consists of slope exceeding 20 percent, the vertical accuracies can be scaled by a factor of 2.0 to account for the complex terrain.

5 Absolute Vertical Accuracy ($LE90_{ABS}$) for each level are goals (not threshold requirements) but the estimated value should be reported in the metadata.

4.4 Data Product and Delivery

4.4.1 Overview

In order to facilitate ingestion and processing of DGED products, the file structure and file naming conventions for geospatial datasets, their associated metadata files and auxiliary resources (such as quality information) must be defined and documented. File names should also be meaningful to humans. Because XML is often used to encode other file types, NEMIS metadata file names should consist of the dataset file name appended with '_meta.xml'.

4.4.2 Coordinate Reference Systems

Elevation datasets, and the applications that generate them, must account for three different surfaces, defined by NGA.STND.0036_1.0.0_WGS84.

1. The Earth's topographic surface, including land elevation (hypsometry) as well as the underwater equivalent (bathymetry).

2. The ellipsoid, a mathematical reference surface approximating the general size and shape of the Earth.

3. The geoid, an equipotential surface of the gravity field of the Earth that is the reference surface for orthometric heights.

A horizontal datum is a set of geodetic quantities which attaches a coordinate system to the physical Earth. A horizontal datum is necessary for large-scale mapping, charting, and geospatial applications requiring precision. Without a horizontal datum, coordinates remain imprecise or ambiguous. The World Geodetic System 1984 (WGS 84) is the standard horizontal datum for the DoD, as set forth in MIL-STD-2401, Department of Defense World Geodetic System (WGS). The WGS 84 reference frame is updated periodically by the DoD based on GPS satellite observations. These updates are called WGS84 realizations (Table 4-6). Satellite-derived elevation values are often measured as ellipsoid heights in the WGS 84 realization corresponding to the period over which the source imagery was collected.

Table 4-6. WGS 84 realizations

Name	Datum Epoch	Remarks	Shift (m)
WGS 84	1984	First realization established by DoD in 1987 using Doppler observations. Also known as WGS84 (1987), WGS84 (original), WGS84 (TRANSIT).	N/A
WGS 84 (G730)	1994.0	Realization introduced by DoD on 1994-06-29 based on GPS observations.	0.70
WGS 84 (G873)	1997.0	Realization introduced by DoD on 1997-01-29 based on GPS observations.	0.20
WGS 84 (G1150)	2001.0	Realization introduced by DoD on 2002-01-20 based on GPS observations.	0.06
WGS 84 (G1674)	2005.0	Realization introduced by DoD on 2012-02-08 based on GPS observations.	0.01
WGS 84 (G1762)	2005.0	Realization introduced by DoD on 2013-10-16 based on GPS observations.	0.01

Note: G stands for “GPS” and the adjacent value represents the GPS week number.

The World Geodetic System 1984 (WGS 84) represents the best global geodetic reference system for the Earth available at this time for practical applications of mapping, charting, geopositioning, and navigation. Datasets in geographic coordinates (latitude and longitude) should use a realization of WGS 84 (NGA.STND.0036_1.0.0_WGS84).

Because the ellipsoid-based, geographic coordinate system is a non-rectangular system of angular rather than linear units, it is often unsuitable for land-based operations that require accurate distance and area measurements. This is particularly true for high-resolution datasets at high latitudes, where latitude and longitude have different scales and feature morphology may appear distorted (see Section 4.2.6). To address this shortcoming, data is often projected to the Universal Transverse Mercator (UTM) or Universal Polar Stereographic (UPS) coordinate reference systems (NGA.STND.0037_2.0.0_GRIDS). UTM is generally used between 84° N and 80° S latitude while UPS is used for data falling above 84° N and below 80° S. Datasets in projected coordinates should use the UTM or UPS zone where the product is located, according to the tiling schemes described in Section 4.4.3. Each UTM and UPS zone shall be registered to the WGS 84 datum.

For ease of use across the DoD elevation user community, it is recommended that the vertical dimension be specified in orthometric heights relative to the Earth Gravitational Model (EGM), in accordance with NGA.SIG.0025_1.0_EGM. At the time of publication, NGA has established EGM2008 as the model for the geoid from which orthometric heights are derived for use in the NSG (NGA.SIG.0007_1.0_EGM2008). However, NGA will soon release the EGM of 2020 (EGM2020), which will benefit from additional data sources and provide improved global resolution.

Satellite-derived elevation data often uses the WGS 84 geodetic 3D coordinate reference system (CRS), including height-above-the-ellipsoid (HaE), as that is the datum used by GPS technology. While this is acceptable for data in geographic coordinates (latitude and longitude), the use of HaE in projected datasets is discouraged. ISO 19111 prescribes that ellipsoidal height can only be used as part of a three-dimensional ellipsoidal CRS or as part of a three-dimensional projected CRS, but never on its own. As a result, no vertical CRS or “hybrid” projected 3D CRS has been defined in the EPSG Geodetic Parameter Dataset, which is maintained by the Geodesy Subcommittee of the International Association of Oil and Gas Producers (IOGP) and regarded as the most comprehensive CRS registry.

EPSG codes are recognized by software packages such as ArcGIS and QGIS, which provide translations between most codes. Because HaE is not defined as a vertical CRS, these software packages cannot easily convert between HaE and orthometric heights. Most of NGA’s elevation customers are accustomed to working with orthometric heights, and the use of HaE in some datasets may introduce operational challenges, particularly for very large files, as they must be converted to a common datum prior to exploitation.

4.4.3 Custom Product Tiling

A standardized tiling scheme makes it easier to aggregate data across large areas, merge multiple collections, resample to different resolutions, and detect temporal changes. Untiled data may be acceptable for small coverages less than approximately 10,000 posts per side at the chosen resolution. Areas larger than this should be tiled in order to improve their usability and interoperability with other NSG elevation data. There are multiple potential tiling schemes and the community to should continue to explore these to identify the most appropriate method considering technology advancements (software and hardware) and applications. However, in an effort to standardize current and near-term elevation products, it is strongly recommended that elevation data be tiled according to the tiling schemes outlined in this SIG. The tiling schemes are designed to keep uncompressed GeoTIFF file sizes below approximately 400 MB per tile, with a maximum of 10,000 GSD intervals per side. Custom elevation grids much larger than this are expensive to process and may require long download times. The non-geographic tiling scheme in Table 4-8 also allows tiles to be kept below 100 MB uncompressed for better performance on devices with limited bandwidth or memory. For large areas, it is often more efficient to load multiple tiles into a workspace than to combine all elevation data into a single gridded file.

The number of grid posts per tile edge is equal to the number of GSD intervals per tile plus one. The eastern and northern edges of each tile overlap with the western and southern edges, respectively, of its neighboring tiles. Consequently, all edge posts shall have identical elevations as the adjoining cells (referred to as “edge matching”).

DGED Levels 4, 5, 6, 7, 8, and 9 are designed to fit together within a single Universal Transverse Mercator (UTM) or Universal Polar Stereographic (UPS) zone, sharing common edges. Tile sizes have been selected to allow edges to be split in half (creating quadrants) for easier file storage, processing, and transmission. This structure is known as a quadtree. The quadtree structure is useful for subdividing an area of interest in order to collect elevation at different ground sample intervals. For large areas of interest, the highest resolution data may only be available over a small area, while lower resolution data may have broader coverage. Use of a quadtree organization allows void-free tiles to be generated where data coverage exists, then resampled and combined with other datasets to create larger, lower level (larger GDS) tiles with minimal loss of detail. In addition, DGED levels allow two tile sizes for UTM-projected data in order to support more flexible product distribution and bandwidth requirements. Figure 4-3 shows an example quadtree structure for DGED levels 4, 5, 6, 7, and 8.

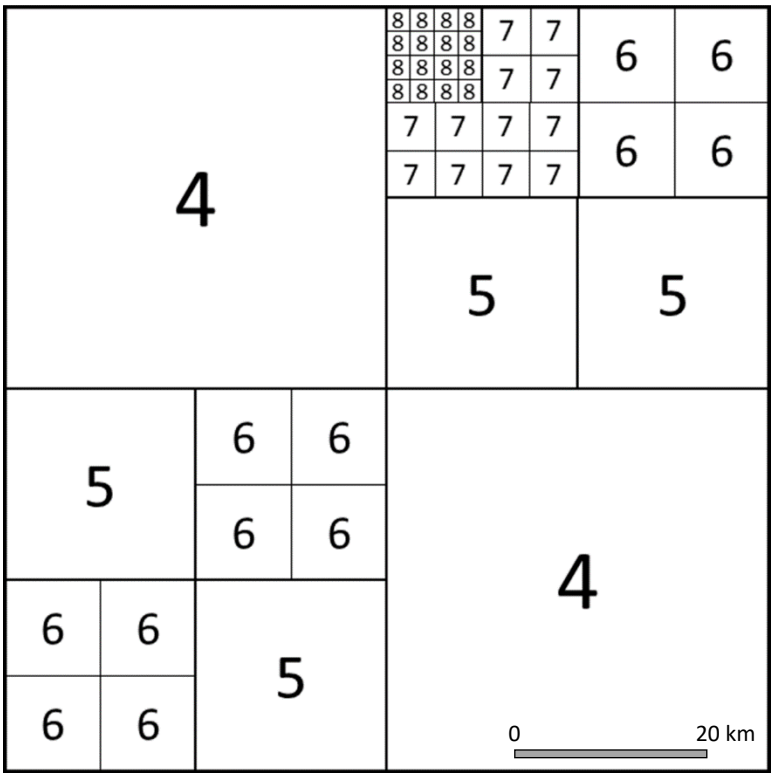

Figure 4-3. Example quadtree structure with tiles from DGED Levels 4-8

4.4.3.1 Geographic Tiling Scheme

Low- to medium-resolution data should be tiled in geographic format using one-degree or quarter-degree cells. The number of intervals in longitude varies according to the longitudinal factor specified in Table 4-2. The maximum number of longitudinal posts is equal to the number of latitudinal posts in Zone 1 (50° S - 50° N).

Table 4-7 shows the approximate ground sample distance and tile size (posts per degree of latitude) for low- to medium-resolution elevation content in geographic projection. The maximum GeoTIFF file size assumes an equal number of posts in latitude and longitude and no compression.

Table 4-7. Geographic tiling scheme and size options

DGED Level	GSD (arc seconds)	Approx. GSD (m)	Width in latitude (minutes)	Approx. width in meters	Number of posts in latitude	Encoding	Max. GeoTIFF file size (MB)
0	30	*1,000*	60	*110,000*	121	16-bit	0.03
1	3	*100*	60	*110,000*	1,201	16-bit	3
2	1	*30*	60	*110,000*	3,601	16-bit	25
3	0.4	*12*	60	*110,000*	9,001	16-bit	155
						32-bit	309
			30	*55,000*	4,501	16-bit	39
						32-bit	77
4b	0.15	*5*	15	*28,000*	6,001	32-bit	137
4	0.12	*4*	15	*28,000*	7,501	32-bit	215
5b	0.09	*3*	7.5	*14,000*	5,001	32-bit	95
5	0.06	*2*	7.5	*14,000*	7,501	32-bit	215
6	0.03	*1*	3.25	*7,000*	7,501	32-bit	215
7	0.015	*0.5*	1.625	*3,500*	7,501	32-bit	215
8	0.0075	*0.25*	0.8125	*1,750*	7,501	32-bit	215
9	0.00375	*0.125*	0.40625	*865*	7,501	32-bit	215

4.4.3.2 UTM and UPS Tiling Scheme

Edge lengths have been chosen to ensure that there is an even, integral number of ground sample intervals in the tile. The Level 5b tile sizes are required to be unique in order to meet this requirement. Because of the odd-numbered GSD in Levels 4b and 5b (five and three meters, respectively), these tiles are not compatible with the quadtree structure supported by the remaining DGED levels. Not all posts will be retained when resampling to the higher levels, resulting in interpolation and a loss of accuracy. For this reason, custom elevation products at DGED levels 4b and 5b are discouraged for tiled datasets.

Table 4-8 provides recommended tiling size options for high-resolution UTM and UPS products.

Table 4-8. UTM and UPS tiling scheme and size options

DGED Level	GSD (m)	Tile edge length (m)	Number of edge posts	Max. GeoTIFF file size, 32-bit (MB)
4b	5	40,000	8,001	244
		20,000	4,001	61
4	4	40,000	10,001	382
		20,000	5,001	95
5b	3	30,000	10,001	382
		15,000	5,001	95
5	2	20,000	10,001	382
		10,000	5,001	95
6	1	10,000	10,001	382
		5,000	5,001	95
7	0.5	5,000	10,001	382
		2,500	5,001	95
8	0.25	2,500	10,001	382
		1,250	5,001	95
9	0.125	1,250	10,001	382

4.4.3.3 UTM Tile Identification System

Data between 84°N and 80°S should be produced using the UTM tile identification system. In order to improve standardization and communication of tile boundaries within each UTM zone, NGA utilizes a UTM tile identification system. Adhering to this tiling scheme will assure that coincident tile footprints are maintained for each DGED level within a UTM zone and across all data products. This maximizes the accuracy of DEM merging and decimation of high-resolution data to lower resolutions as it reduces the need for interpolation.

The file naming convention defined in this document requires that all tiled UTM DGED grids be named according to each tile's southwest geographic coordinate. The tiling system is constructed using the intersection of designated lines of longitude and latitude to define the X and Y axes of a Cartesian plane. Tiles within each UTM zone originate at the equator (*x* axis) and the central meridian (*y* axis) of the zone. Each tile is constructed using the orthogonal intersection at this origin point and the tile edge length defined in Table 4-8. Tile IDs are named based on three components: tile size, number of tiles north of the origin point, and number of tiles east of the origin point. Each component is delimited by the "_" character. Figure 4-4 demonstrates an example of this tiling scheme for DGED Level 4 tiles in UTM Zone 36N. Note that the equator and the zone's central meridian define the *northern* extent of tiles in the southern hemisphere, so for example the tile below 40k_0_0 is named 40k_-1_0.

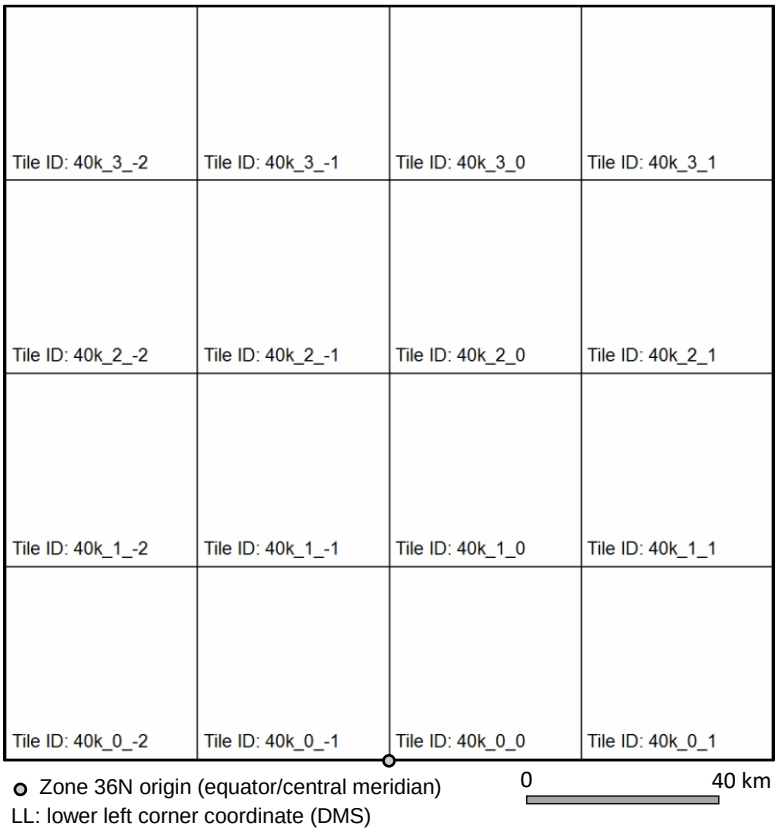

Figure 4-4. Example DGED Level 4 tile locations in UTM Zone 36N

UTM zone boundaries converge at higher latitudes. Some tiles constructed according to this scheme will fall partially or completely outside the corresponding UTM zone. Tiles located completely outside the UTM zone boundaries (as defined by the western and eastern meridians) are invalid and should not be created; instead, this terrain shall be tiled within the UTM zone where it is located. Data producers should follow the UTM zone exceptions identified in NGA.STND.0037_2.0.0_GRIDS. Table 4-9 and Table 4-10 show the exceptions which occur near southern Norway and Svalbard. In the zones identified in the

tables, data producers should utilize the central meridian and equator intersection of the given UTM zone to establish the origin of the tile identification for the exception areas.

In order to prevent voids and ensure consistent coverage, tiles that partially lie outside the UTM zone should not be cropped at the zone boundary. This means that some elevation data near UTM zone boundaries will be tiled twice: once in each of the UTM zones that the tile overlaps. Overlapping tiles shall be seamless; there should be no horizontal or vertical bias between tiles constructed from the same source data.

Between 56° N and 64° N, UTM grid zones 31 and 32 adhere to the following limits:

Table 4-9. UTM Zone Exceptions for Southern Norway

UTM Grid Zone	Westernmost Extent	Easternmost Extent
31	0° E	3° E
32	3° E	12° E

Between 72° N and 84° N, UTM grid zones 32, 34, and 36 do not exist. Zones 31, 33, 35, and 37 adhere to the following limits:

Table 4-10. UTM Zone Exceptions near Svalbard

UTM Grid Zone	Westernmost Extent	Easternmost Extent
31	0° E	9° E
33	9° E	21° E
35	21° E	33° E
37	33° E	42° E

Figure 4-5 shows DGED Level 4 tiles for a single UTM zone in the northern hemisphere. Tiles are only valid if they fall partially or completely within the UTM zone. As the latitude increases, fewer tiles are required to cover the width of the zone.

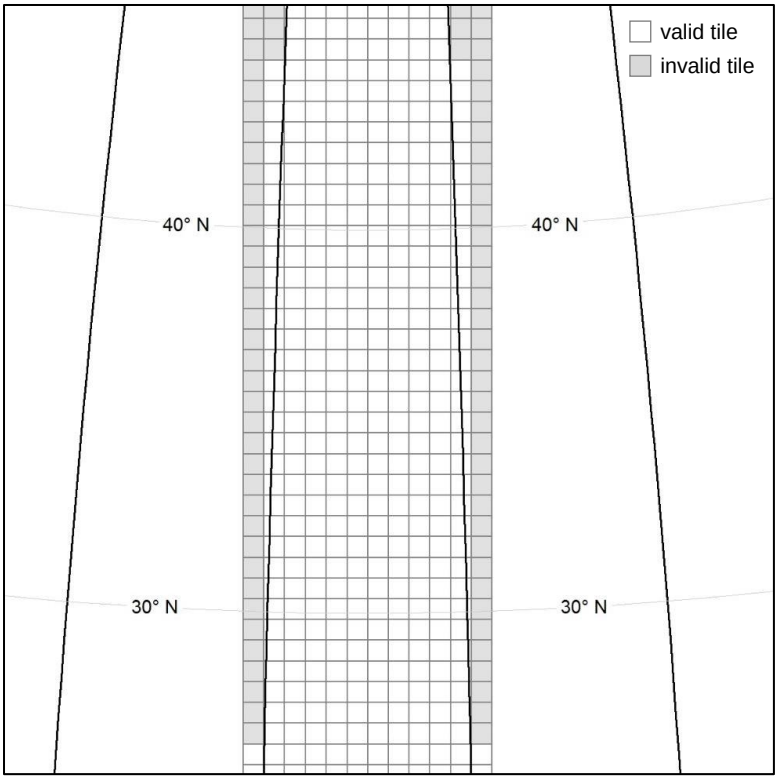

Figure 4-5. Example DGED Level 4 (40 km) tiles within a single UTM zone

4.4.3.4 UPS Tile Identification System

Data north of 84°N or south of 80°S should be produced using the UPS tile identification system. In order to improve standardization and communication of tile boundaries within each UPS zone, NGA utilizes a UPS tile identification system. Adhering to this tiling scheme will assure that coincident tile footprints are maintained for each DGED level within UPS zone and across all data products. This maximizes the accuracy of DEM merging and decimation of high-resolution data to lower resolutions as it reduces the need for interpolation.

The file naming convention defined in this document requires that all tiled UPS DGED grids be named according to each tile's lower-left coordinate. The tiling system is constructed using the intersection of designated lines of longitude and latitude to define the X and Y axes of a Cartesian plane. Tiles within a UPS zone originate at the intersection of longitude E 90°/ W 90° (x axis) and longitude E 0° / E 180° (y axis). Each tile is constructed using the orthogonal intersection at this origin point and the tile edge length defined in Table 4-8. Tile IDs are named based on three components: tile size, number of tiles above the origin point, and number of tiles east of the origin point. Each component is delimited by the "_" character.

Figure 4-6 demonstrates an example of this tiling scheme for DGED Level 4 tiles in UPS Zones A and B.

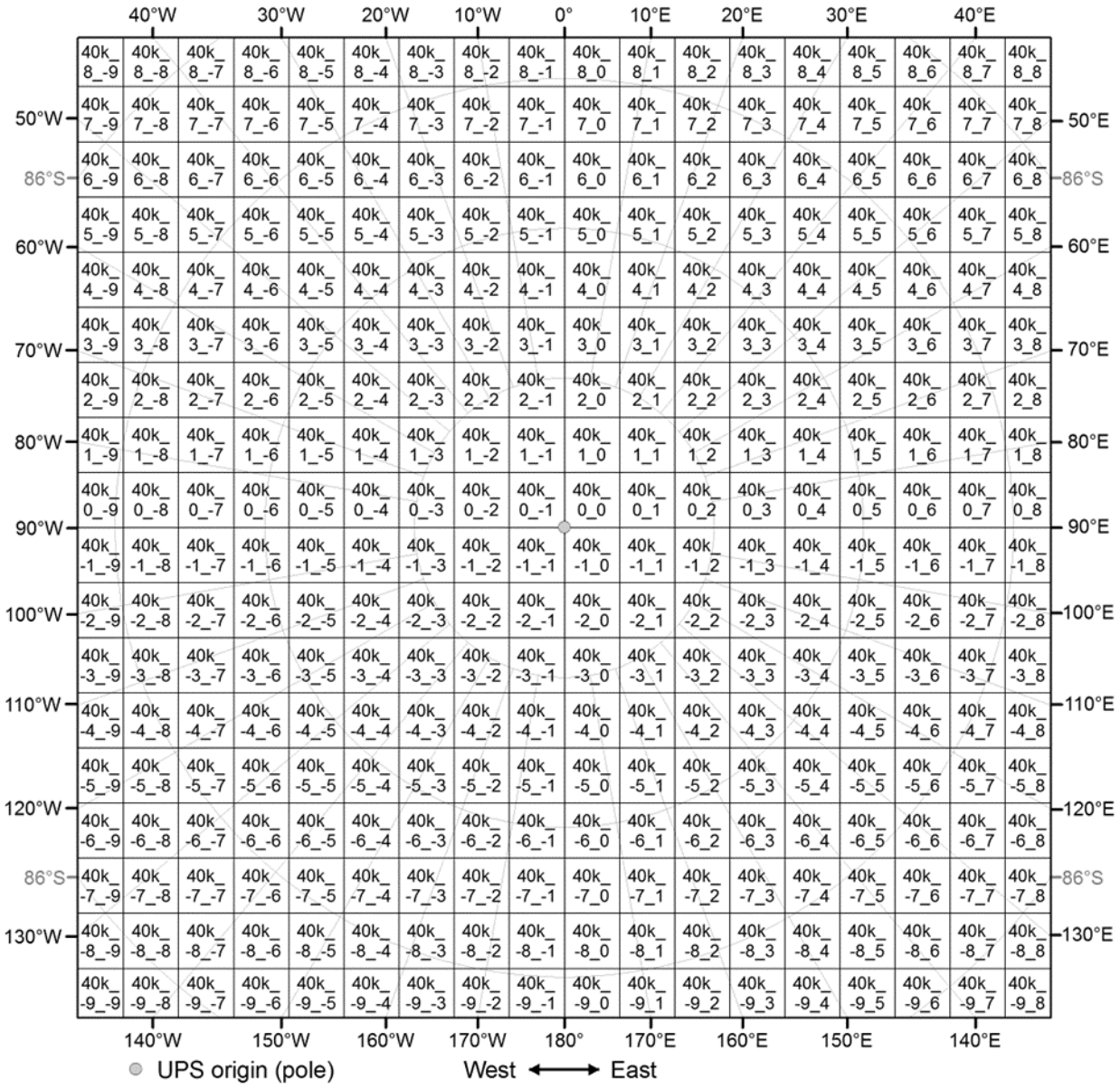

Figure 4-6. Example DGED Level 4 tile locations in UPS

4.4.4 Grid File Naming Convention

Each tile of data is given a unique designation following a defined naming scheme, which is intended to create continuity across the NSG for efficient human identification of elevation content and semi-automated data indexing. This naming scheme is applicable to the tile designation as well as the naming of individual files belonging to one tile. The coordinates given in the tile designation and file names always refer to the southwest (geographic, UTM) or lower left (UPS) corner of the tile.

Tile designations, file and folder names should use the following naming conventions.

Geographic data:
C[_DIS]_DD[MM][SS]hDDD[MM][SS]e[_SIZ]_yyyy[mm][dd]_PROGRAM_CREATOR_TYPE_GSDu_VV[.ext]

UTM and UPS data:
C[_DIS]_ZNxxxxxxeexxxxxxxhh[_SIZ]_yyyy[mm][dd]_PROGRAM_CREATOR_TYPE_GSDu_VV[.ext]

The individual elements are described and defined in Table 4-11. Within Table 4-11, square brackets indicate a range of numeric values, curly brackets indicate a limited set of allowed values, and underscores are used as literals to structure the designations. For all numeric elements, zero padding is used to the maximum possible number of places for readability and automatic processing.

Table 4-11. Naming convention elements definition

Variable	Description	Identifier
C	Classification (compliant with the NSG Metadata Implementation Specification-Information Security Marking Requirements)	C= {U, S, TS, C}, with U = Unclassified, S = Secret, TS = Top Secret, C = Confidential
[_DIS]	Dissemination controls (compliant with the NSG Metadata Implementation Specification-Information Security Marking Requirements)	DIS = {FOU, DS, NF, REL_*}, with FOU = FOUO, DS = LIMDIS, NF = NOFORN; REL_ is followed by one or more valid GENC trigraph or CAPCO coalition tetragraph codes, *e.g.*: USA, FVEY, AUS, CAN, GBR, NZL, etc.
DD	Latitude of SW corner of tile	if h = n: DD = [00, 89]; if h = s: DD = [01, 90]
[MM]	Minutes of latitude/longitude of SW corner	MM = [00, 59]; required for high resolution data and medium resolution data where tile size < 1 degree
[SS]	Seconds of latitude/longitude of SW corner	SS = [00, 59]; required for high resolution data
h	Latitudinal hemisphere of SW corner of tile	h = {n, s} with n = North, s = South
DDD	Longitude of SW corner of tile	if e = e: DD = [000, 179]; if e = w: DD = [001, 180]
e	Longitudinal hemisphere of SW corner of tile	e = {e, w} with e = East, w = West
ZN	UTM or UPS Zone	if UTM: ZN = [1N, 60N] and [1S, 60S] if UPS: ZN = {A,B,Y,Z}
x	Meters	Meters in Easting and Northing at lower left corner of tile in identified UTM Zone, rounded to the nearest integer
hh	Northing	hh = n
ee	Easting	ee = e
[_SIZ]	Size of tile, if data conforms to tiling guidelines in Section 4.4.3.	Geographic, Levels 0-3: width in latitude {1deg, 30min}; Geographic, Levels 4b-9: approximate width in meters in Table 4-7 followed by “km” for Levels 4b-6 or “m” for Levels 7-9; UTM, Levels 4b-9: tile edge length in Table 4-8 (or N-S width in meters for custom grids), followed by “km” for Levels 4b-6 or “m” for Levels 7-9
_yyyy	Year of data collection; if multiple sources are used, this is the earliest source date	
[mm]	Month of data collection; if multiple sources are used, this is the earliest source date	mm = [01, 12]; optional
[dd]	Day of data collection; if multiple sources are used, this is the earliest source date	dd = [01, 31]; optional
_PROGRAM	Program or dataset name	Up to 8 alphanumeric characters identifying the specific program name
_CREATOR	Creator or owner name	Up to 8 alphanumeric characters identifying the creator or owner of the data
_TYPE	Elevation model type	TTT = {DSM, DTM, DHM, BATH, LR, FR}, with DSM = Digital Surface Model, DTM = Digital Terrain Mode, and DHM = Digital Height Model (DSM – DTM), BATH = Bathymetry, LR = Last Return, FR = First Return
_GSD	Ground sample distance	Levels 0-6: GSD = {1000, 100, 30, 12, 5, 4, 3, 2, 1} (m); Levels 7-9: GSD = {50, 25, 12} (cm); integer only (see Table 4-1)
u	Unit of ground sample distance	u = {m, cm} with m = meter (Levels 0-6), cm = centimeter (Levels 7-9)
_VV	Version number	VV = [01, 99]
[.ext]	File format extension (for files only)	.ext = {.tif, .xml}

Additional detailed information on delivery, quality and description of product is provided within the metadata (XML) file; therefore, the file name need not duplicate this content. Information indicated in the

file name must align with the information provided by the metadata. In case of any inconsistency, metadata information prevails. Therefore, applications accessing datasets shall utilize the metadata for file indexing.

Example file names are shown below. The names are for illustration only, as corresponding datasets do not exist.

- U_27n056e_ 1deg_2016_DGED_NGA_DTM_30m_01.tif
- U_LIM_14n034w_ 1deg_2017_DGED_GE_DSM_12m_02.tif
- S_REL_FVEY_32N280000e03970000n_10km_2018_DGED_NGA_DTM_1m_01.tif
- U_FOU_9N350000e06090000n_5km_20160823_BUCKEYE_AGC_DSM_50cm_01.tif

4.4.5 File Format and Encoding

Custom elevation content should be encoded in GeoTIFF format in accordance with the DGIWG's GeoTIFF Profile for Georeferenced Imagery (DGIWG – 108). Low-resolution content should be encoded as 16-bit signed integer. Because the quality of sources may vary, medium-resolution elevation datasets may be encoded as 16-bit signed integer (to reduce file size) or signed 32-bit floating point (to preserve detail).High-resolution content should always be encoded as 32-bit floating point.

The following guidelines should be considered when encoding GeoTIFF files with elevation data:

1. Each TIFF-encoded tile is a baseline TIFF as defined in the Part 1 of the TIFF standard (TIFF Specification 6.0). The use of any private tags, other than those in the baseline TIFF fields, is prohibited. Additional information that may be required by the producer should be included only in supplemental XML data.
2. Tiles are encoded as a single-band image using one signed 16-bit or floating-point 32-bit component per pixel (i.e., for any pixel in the TIFF tile, there shall be only one value).
3. All pixels in the tile shall be set with a valid component value. NULL (or missing) values are represented by a designated "out-of-range" value, typically the most negative value available for the data type selected (or the non-number value designated for the selected data type), which must be explicitly declared by using the GDAL_NODATA tag if there are NULL values.
4. No multi-image/tiling extensions defined in TIFF should be used.
5. GeoTIFF files may be compressed using the LZW compression algorithm, although this extension may not be supported by all software applications. LZW compression can also be handled outside the TIFF specification (e.g., by zipping the GeoTIFF file). LZW is a lossless compression that may perform efficiently on some elevation grids, such as when large areas have the same pixel values (e.g., large water bodies).

5 Point Cloud Data

5.1 Introduction

This section defines the file formats and data storage for point clouds required to support National System for Geospatial Intelligence (NSG) and Allied System for Geospatial Intelligence (ASG) interoperability. These parameters define how point cloud datasets are to be ingested, retained, discovered, and exploited. Point clouds include data derived from airborne/terrestrial Light Detection and Ranging (LiDAR), Synthetic Aperture Radar (SAR) and Electro-Optical (EO) sources.

In addition to the point data structure and file formats, this section addresses unique metadata associated with data quality, pedigree, and content. Where possible, this SIG leverages existing DoD/IC, civilian, academic, and industry point cloud standards. The following metadata and storage guidelines are imperative due to the potential impact on cost, risk, and efficiency necessary to support the GEOINT mission throughout the entire DoD/IC analytical chain (*i.e.*, processing, visualization, and analysis).

5.2 Point Cloud Levels

In 2011, NGA and the GEOINT community defined a series of point cloud processing levels. These levels provided a convenient method to bin LiDAR products based on their status in the processing chain and socialize the processing status of LiDAR derived point cloud data during dissemination. As LiDAR point clouds were disseminated, the processing level would also be provided to give the downstream recipient a general idea of the processing that was performed on the data and the expected characteristics of the dataset. This level was often encoded into the file name to provide users an immediate indication of dataset.

Due to the convenience offered by these processing levels, it is beneficial to generalize the previous work and define point cloud processing levels that are sensor- and modality-agnostic. The list below provides recommended generalized processing level definitions for all types of point cloud data.

- **Level 0 – Pre-Point Cloud Data**: This data consists of the raw data in the form it is stored as collected from the remote sensing platform or as derived in pre-processing steps that occur prior to point cloud generation. This is the raw data used to create point cloud data, but it has not yet been processed to a point cloud model. The dataset includes, but is not limited to, data from GPS (position), IMU (orientation), laser measurements (timing, angles), EO images, and gimbal(s). While formerly called Raw Data in the LiDAR Processing Levels, Level 0 also includes data that has gone through initial processing stages, but has not been formed into a point cloud. Some Level 0 components may be specified and controlled by external standards. For example, there may be standards that specify image format and the metadata content (*e.g.,* STDI-0002, Appendix Z, SENSRB).
- **Level 1 – Initially Processed Point Cloud Data:** This point cloud level consists of point coordinates for objects measured by the remote sensing system. It is the result of applying algorithms (sensor models, Kalman filters, photogrammetric ray intersections, dense matching, etc.) in order to project the Level 0 data into 3D-space. The points may be computed based on a direct active measurement, such as linear mode LiDAR, or from an indirect solution, such as a multi-ray intersection. The Level 1 product is the initially processed point cloud data and may be noisy, contain data artifacts, or not be properly georegistered.
- **Level 2 – Intermediate Point Cloud Data**: This data is an intermediate processed point cloud where additional algorithms have been applied on the Level 1 data. Examples of the additional processing include noise removal (coincidence processing), flattening / surface-finding, and

relative alignment between adjacent products from the collection. Datasets at this level are commonly provided in absolute coordinates (a well-defined coordinate reference system), but may not be adjusted to ground truth and located at their final geopositions.

- **Level 3 – Exploitable Point Cloud**: This data consists of the primary exploitation-ready point cloud product that is engineered for human visual interpretation and ready for subsequent point cloud exploitation algorithms to be applied. The data is georegistered to absolute coordinates and has the “noise” removed. A Level 3 data product often consists of an aggregation of multiple individual looks or scenes and may be tiled into smaller, more manageable portions. For Geiger mode LiDAR point clouds, intensity is normally calculated during the aggregation process and thus is included in the per-point information for a Level 3 product. Level 3 products should also include metadata needed for exploitation. Level 3 datasets are point cloud products that are typically stored and disseminated in a system such as GRiD.
- **Level 4 – Derived Products:** Level 4 products can be both raster products derived from the point clouds and the point clouds with additional derived attributes. For point clouds, these attributes are typically intensity (normally already in the Level 3 product) and per-point classification values. Other point cloud products, such as a human activity layer, may also be generated. For raster products, Level 4 data consists of elevation products including Digital Surface Models (DSMs), Digital Terrain Models (DTMs), and Triangulated Irregular Networks (TINs). Level 4 data can also consist of non-elevation auxiliary raster data (*e.g.*, intensity values, viewshed, classification values, and masks). Level 4 products may no longer be a point cloud and, as such, may be controlled by other external standards and specifications.

While point cloud data can be stored and disseminated at many stages in the processing chain, the primary point cloud product for exploitation is the Level 3 point cloud. Therefore, NEMIS metadata is applicable to these Level 3 products.

It should be noted that the Conceptual Model and Metadata Dictionary (CMMD) defined Enterprise Processing Levels that were slightly different than the LiDAR Processing Levels and are therefore different than the levels described above. The Enterprise Level 1 was an intermediate processing stage wherein the “raw” data was converted into an Enterprise format in order to pass through a common processing chain. This caused an offset between subsequent CMMD levels and the Point Cloud Levels. There were also additional differences between the levels beyond this simple offset. Therefore, no look-up between the CMMD and Point Cloud Levels is provided here.

5.3 Dataset File Formats

5.3.1 Overview

This section identifies the most common file formats for point cloud data within the NSG. A file that adheres to an agreed-upon format provides content, quality, and consistency for basic data integrity checks.

5.3.2 LASer File Format (LAS)

The LAS file format was developed by the American Society for Photogrammetry and Remote Sensing (ASPRS) specifically for LiDAR point cloud data records. The intention of the LAS file format is to provide a mechanism that allows different LiDAR hardware and software tools to output data in a common format and support growing LiDAR data and metadata requirements. NGA is experiencing rapidly changing requirements for LiDAR, including the need for temporal data, mapping mode and target mode use cases, and evolving sensors and sensor models. The LAS format supports existing mission requirements and rapidly evolving LiDAR sensor technology.

The LAS 1.4 specification has several advantages over the earlier LAS 1.2 and LAS 1.3 specifications. First, it is widely used by both commercial industry and the government. Therefore, most government off-the-shelf (GOTS) and commercial off-the-shelf (COTS) point cloud analysis and exploitation tools support it. Second, LAS 1.4 introduced the ability to use Well-Known Text (WKT) for coordinate reference systems, enabling more flexibility than was previously supported with GeoTIFF keys. Third, LAS 1.4 has added the flexibility of defining additional per-point attributes using a standard definition methodology that makes those elements self-discoverable. Finally, LAS 1.4 has added Extended Variable Length Records (EVLRs) which allow for the storage of additional metadata at the end of the point cloud file.

Any required or optional metadata, as specified by this document, that is not part of the point record and cannot be stored within the primary headers and subheaders of the LAS should be stored as Variable Length Records (VLRs) or Extended Variable Length Records (EVLRs) within the LAS as defined within the LAS 1.4 specification. The metadata content within the VLR may be stored using XML that is not required to meet the NEMIS specification. This offers the advantage that common point cloud metadata attributes, such as those identified in Section 6.2, not supported by the NEMIS (due to current limitations of the NAS) can be embedded in the LAS file, ensuring their availability to data users and software programs.

Additional per-point attributes that extend beyond the point data templates in LAS 1.4 should use the predefined mechanism for defining additional metadata within the LAS 1.4 file. The additional per-point attributes should be defined in a VLR as documented in the LAS 1.4 specification to allow the data to be discoverable to those that may not be familiar with the specific file of interest.

5.3.3 LASzip (LAZ)

LASzip is an open source software product of the company rapidlasso GmbH (https://rapidlasso.com) that is used to compress American Society of Photogrammetry and Remote Sensing (ASPRS) LAS-formatted point cloud files into compact LAZ files using a lossless compression algorithm. It is available as a stand-alone software library to allow other applications that handle LAS data to read and write LASzip-compressed data. This compression into LAZ files makes it easier to store, copy, transmit, or archive large amounts of LIDAR due to the large reduction in file size (generally 50-90 percent). LASzip is widely used in the DoD/IC community and has been incorporated into GRiD and point cloud exploitation tools (*e.g.*, Quick Terrain Modeler and ENVI LiDAR).

It is recommended that LAS files be compressed to LAZ format using LASzip prior to uploading to the cloud for retrieval by GRiD or a similar content management service.

5.3.4 National Imagery Transmission Format (NITF)

In certain situations, LAS files may be NITF-wrapped so that the binary data of the LAS file is stored within a NITF container. This is useful when working with legacy software systems in the NSG because NITF has extensive metadata definitions of interest to the DoD/IC already defined in Tagged Record Extensions (TREs) and is a format that is commonly used in the DoD/IC (see Appendix A of the LiDAR Data Interoperability Guide). Therefore, NITF wrappers are sometimes required to ingest data into legacy storage systems. NITF wrappers can also be beneficial for encoding and transmitting items such as thumbnails of the data of interest. Even when NITF-wrapped files are used, it is recommended that the metadata defined within this guidance document still be stored within VLRs and NEMIS XML files, even if that metadata is reported in the NITF TREs. This redundancy will ensure that key metadata continues to live with the point cloud, even if the points are extracted from the NITF and the NITF headers / TREs are discarded.

5.3.5 Binary Point File (BPF)

The Binary Point File (BPF) format was initially designed by the Johns Hopkins Applied Physics Laboratory (APL) to serve as a lightweight, quick, binary file format for the storage of unorganized point cloud data and became a *de facto* standard when working with the APL's various processing algorithms and utilities. Since that time BPF has been adopted by multiple groups within the DoD/IC and undergone several revisions. Updates to the format were proposed by MIT Lincoln Laboratories (MIT/LL) and others with MIT/LL providing many of the enhancements for BPF2 and BPF3. BPF has been incorporated into

various point cloud exploitation capabilities and an NGA Information Guide (NGA.SIG.0020_1.1_BPF3) was developed in August 2015 to formalize BPF.

One limitation within BPF is the spatial coordinate systems supported. BPF only supports Cartesian, UTM, TCR, and ENU coordinate systems. Geodetic coordinate systems are not supported by BPF.

If BPF is used, NGA.SIG.0020_1.1_BPF should be used as the official reference for the format. Additional metadata that cannot be stored in the point records should be stored in bundled files in the BPF file header, similar to the VLRs in LAS (Section 6.2.1).

5.3.6 Entwine Point Tile (EPT)

Entwine Point Tile (EPT) is an open source tile service definition for point cloud data that has been demonstrated to support extremely large collections of data. EPT provides a number of useful features that provide potential advantages for applications looking to leverage large collections of point cloud data. First, it describes an octree access structure for the three-dimensional point cloud data. Octrees mirror the geographic tiling schemes described in Section 4.4.3, in three dimensions instead of two. Second, it was designed to operate and leverage cloud computing infrastructure such as AWS S3, Google Cloud Storage, or Azure Blob Storage. Third, it is agnostic in regard to content encoding of the data. LAS and LAZ can conveniently work in EPT, but other point cloud content encoding types are possible; EPT simply provides the tiling access infrastructure for applications looking to leverage and extract information from the data. The specification for EPT can be found online at https://entwine.io/entwine-point-tile.html.

EPT was designed to provide a lossless data structure for content. Lossless for EPT is defined to be lossless in terms of point content (store all points to any potential tree depth), lossless in terms of content organization (preserve previous data insertion ordering to recreate source information), and lossless in terms of metadata capture. These features make EPT suitable for providing point cloud web services for data infrastructure.

5.3.7 Modality-Independent Point Cloud (MIPC)

Moving forward, the NSG may provide support for an HDF5 file structure with the specific data and metadata structure defined by the Modality-Independent Point Cloud (MIPC) standard (NGA.STND.005-01_1.0_MIPCDIDD). MIPC, partly as a result of the HDF5 file format, provides a file storage and dissemination alternative that has been tailored to the needs of the DoD/IC. The main near-term drawback to MIPC is the lack of adoption with the DoD/IC and the civilian/commercial communities. There is currently limited support within the exploitation, storage, and dissemination tools. Future exploitation of MIPC would rely on development of a reader/writer utility. However, as the community potentially adopts MIPC, the self-describing aspects of HDF and MIPC can be used to capture the additional metadata content within the HDF5 structure (LiDAR Data Interoperability Guide).

5.3.8 Other Formats

In certain cases, it may be required to store and/or deliver data in a nonstandard format. The NSG and GRiD can accommodate non-standard datasets. However, detailed information must be provided regarding the file format.

Additionally, in these cases, it is recommended that a reading and writing utility for the file format be developed and delivered with the non-standard data. While this utility could take multiple forms, the open source Point Data Abstraction Library (PDAL) is recommended due to its tight integration into the GRiD infrastructure. PDAL supports many formats beyond LAS and BPF (*e.g.*, text, MrSID, NITF, SQLite, etc.). The writing capability is required in addition to the reading capability in order to allow GRiD to convert the file to alternate formats more compatible with current processing and exploitation tools.

5.3.9 Point Cloud File Format Feature Comparison

The table below provides a comparison of various point cloud file formats based on a set of 14 features that were identified as important to the community.

Table 5-1. Point cloud file format feature comparison

Feature	LAS 1.2	LAS 1.4	BPF	EPT	MIPC (HDF5)
1. Exploitation supported by commercial industry and tools (COTS)	a	a	b	c	d
2. Exploitation supported by NSG and its data vendors	a	a	b	e	d
3. Existing converters transform data into other common formats	f	f	f	e	f
4. Accommodates required metadata in point cloud product	g	g	g	h	
5. Accommodates additional producer-defined developers metadata	i	i	i	h	
6. Metadata documentation meets NSG/NMF requirements	j	j	j	k	l
7. Accommodates error metadata based on the GPM	m	m	m	m	m
8. Platform independent, portable, binary data				n	
9. Does not impose predefined limit on number of attributes per point	o	o	p		
10. File size is not a limitation	q				
11. Accommodates multiple collections of points from different modalities, with associated metadata, in the same file	i, r	i, r	i, r		
12. Accommodates multiple collections of points across the scene that possess a different list of attributes per point	s	s	s	t	
13. Supports a wide range of standard coordinate systems			u		v
14. Accommodates a per-point, per-dimension, standard deviation	w	w	x		

Legend: **supported** | **partially supported** | **not supported**

Notes:

a. LAS 1.2 is widely used in commercial industry and the NSG. LAS 1.4 widely used in commercial industry, but less widely used to date in the NSG.

b. BPF is widely used in the NSG, but less well known and less used in commercial industry. Tools like Quick Terrain Modeler support BPF.

c. Safe FME and BlueMarble software companies have stated that they support the EPT format.

d. MIPC is new and not currently supported widely in the NSG or commercial industry. The VIPER Point Cloud Viewer, a Government Off-The-Shelf (GOTS) software, supports MIPC. Several Tactical Decision Aid (TDA) algorithms in the ENVI remote sensing software have been modified to work with MIPC data.

e. Open source software provides full support through PDAL.

f. Converters exist to convert between LAS, BPF and other formats, the most versatile of which is PDAL. These converters convert the point data and associated header metadata needed for the points. However, it is not clear to what extent these utilities can convert non-standard metadata between files (*e.g.* conversion of LAS 1.4 VLRs to BPF bundled files). Further consideration is required in order to determine PDAL's ability to convert GPM and other metadata between various file types.

g. See the storage of XML in VLRs as defined in the draft NSG LiDAR Data Interoperability Guide (LIG). A similar concept could be used with BPF.

h. JSON metadata of any organization are supported.

i. See note **p** for per-point limitations. LAS 1.2 and LAS 1.4 formats may store additional metadata via XML in VLRs. BPF can store additional metadata via bundled files.

j. LAS and BPF can accommodate additional metadata via VLRs and bundled files, respectively but official documentation is limited regarding what is to be stored and how it is stored. Historically, NSG-standardized metadata has been captured by wrapping the LAS/BPF within NITF and storing the NSG mandated metadata within the NITF header. LAS 1.4 can replace NITF wrapping by storing NSG standardized metadata in XML format embedded within VLR records. NEMIS XML files can (and should) accompany the point cloud file, but do not eliminate the need to store critical metadata in the VLRs or bundled files.

k. EPT supports LAS VLR records in addition to JSON metadata. However, it has not been vetted by the NSG community.

l. MIPC supports extensive metadata storage based on NSG standards, although it is unclear how much some of the metadata has been vetted by the community.

m. GPM metadata for LAS and BPF are defined in the GPM documentation. MIPC defines an encoding of GPM within HDF5. EPT natively supports GPM metadata in LAS 1.4 VLR records.

n. EPT separates the content encoding from the access pattern. LAZ is commonly used but any content encoding could be supported.

o. LAS 1.2 uses fixed point formats (to include data types for attributes), but in LAS 1.4 users can add additional attributes per point.

p. BPF can have additional attributes per points, but is limited in the bit depth of those attributes. The data type for the point coordinates is fixed.

q. LAS 1.2 files are limited to a 32-bit file structure with a maximum of 2^{32} = 4,294,967,295 points.

r. Points from multiple collections could be stored in a single LAS or BPF file, but the header would not accommodate the per-collect metadata. Some of this could be encoded in VLRs / bundled files.

s. LAS and BPF define a standard point record format across a dataset even if user-defined fields are used. Points that contain different attributes must be split into separate LAS or BPF files which could then be associated using existing metadata (*e.g.*, Point Source ID and File Source ID within the LAS VLRs).

t. The user must create a new resource for each distinct data schema that exists.

u. BPF supports four coordinate systems: Cartesian, Universal Transverse Mercator (UTM), Terrestrial Centered Rotational (TCR), and East North Up (ENU). Geographic projections are not supported.

v. MIPC supports two coordinate systems: Universal Transverse Mercator (UTM) and Earth-Centered, Earth-Fixed (ECEF). Geographic projections are not supported.

w. Per-point standard deviations are difficult to encode in LAS 1.2, but can be captured in LAS 1.4 via user defined attributes.

x. Standard deviations can be encoded in BPF, but the BPF format has limitations with respect to bit depths.

5.4 Accuracy

5.4.1 Standard Accuracy Measurements

The principal horizontal and vertical accuracy measurements to be associated with point cloud elevation data conforming to this SIG are:

Table 5-2. Standard accuracy measurements for reporting

Error Term	Scalar Representation to be Reported	Units
Absolute horizontal accuracy	Absolute Circular Error 90 ($CE90_{ABS}$)	meters
Absolute vertical accuracy	Absolute Linear Error 90 ($LE90_{ABS}$)	meters
Relative horizontal accuracy	Relative Circular Error 90 ($CE90_{REL}$)	meters
Relative vertical accuracy	Relative Linear Error 90 ($LE90_{REL}$)	meters

The terms in the table above are defined in Section 3.1 and are described in more detail in the Accuracy and Predicted Accuracy portion of the NSG: Glossary of Terms (NGA.SIG.0026.02_1.0_ACCGLOS).

5.4.2 Generic Point-cloud Model

The Generic Point-cloud Model (GPM) is a rigorous sensor model developed for the NSG by the Community Sensor Model Working Group (CSMWG). GPM provides for rigorous error propagation, allowing for the development of absolute and relative error estimates for point cloud data. The absolute error estimate can be calculated for any location in the point cloud. The relative accuracy can be computed between any two points in the data. Additionally, a full 3*n* x 3*n* covariance matrix can be computed among any *n* points in the data. GPM also specifies a series of adjustable parameters that can be used to adjust or fuse datasets together whether the adjustment is with additional point clouds or other GEOINT modalities. During the adjustment, the predicted accuracies are used to weight the adjustment between the data, *i.e.* to determine how much each dataset should be allowed to move. GPM is currently the adopted, high-fidelity error propagation and adjustment model for point clouds within the NSG.

Because it is a high-fidelity rigorous model, GPM requires the storage of a series of unique metadata elements. These parameters are organized into multiple sub-groups and there are alternatives to implementation of the model and variations in the format used to store the data and metadata. The details of GPM are too expansive to duplicate within this SIG. Further, GPM cannot currently be mapped into a format that is compliant with the ISO standards or the NMF. Therefore, for details on the GPM model, the reader is referred to the adopted GPM standard (NGA.STND.0046_1.0).

5.5 Data Storage and Dissemination

5.5.1 Overview

The purpose of this section is to provide guidance to GEOINT data providers (*e.g.*, collection, processing and production programs) that would like to integrate their point cloud datasets within the NSG. Currently, elevation data within the NSG is being migrated to the cloud, for distribution through services like GRiD. This is the result of an initiative to use data as a platform for strengthening mission integration across the IC and DoD. Point cloud data delivered to the cloud will be validated and made available to all authorized users and services. NGA is developing GRiD to assist users in discovering, filtering, and retrieving elevation content from the cloud.

5.5.2 Cloud Storage

The cloud represents an evolution in the way NGA's data is stored and accessed. Historically, elevation data has been stored in semi-private data structures, which generally include a catalog search and retrieval capability. In the future, enterprise data services will manage NGA's elevation content and maintain it in common areas accessible to all authorized users, even if the user and use is unanticipated. This is accomplished through the elastic compute concept in cloud computing, in which the cloud service provider can easily scale resources up and down depending on the need. The data will move through an automated validation process prior to acceptance of the data by NGA and distribution through GRiD.

5.5.3 Geospatial Repository and Data Management System (GRiD)

NGA has developed GRiD through a partnership with the U.S. Army Corps of Engineers Cold Regions Research and Environment Laboratory (CRREL) in order to efficiently distribute 3D data, such as point cloud data, as well as 2D geospatial products, such as imagery and DEMs. The system has replaced the Web-based Access and Retrieval Portal (WARP) as the program of record for 3D data for the NSG. GRiD catalogs elevation content and facilitates user discovery of data in the cloud. For a data provider, GRiD offers data distribution, support for multiple data formats, and Oracle-enabled secure user access control based on the elevation metadata information. For a data user, GRiD provides an efficient web-based download mechanism, user-defined filters, and built-in terrain analysis algorithms. GRiD is now operational on the NIPRNet, SIPRNet, and JWICS networks. User authentication via GEOAXIS is available on all three networks.

NIPRNet:	https://grid.nga.mil
SIPRNet:	https://grid.nga.smil.mil
JWICS:	https://grid.nga.ic.gov

5.5.4 Point Cloud File Naming Convention

NGA recommends the following naming convention for point cloud files, which has been modified to accommodate current and emerging sensor modalities. Each dataset is given a unique designation which is intended to create continuity across the NSG for efficient human identification of elevation content and semi-automated data indexing. The geographic coordinates given in the dataset name always refer to the southwest corner of the tile.

Point cloud designations, file and folder names should follow this naming convention:

C[_DIS]_yyyymmdd_DDMMSShDDDMMSSe_MODAL_PROGRAM_NPSu_VV[.ext]

The individual elements are described and defined in Table 5-3. Square brackets indicate a range of numeric values, curly brackets indicate a limited set of allowed values, and underscores are used as literals to structure the designations. For all numeric elements except NPS, zero padding is used to the maximum possible number of places for readability and automatic processing.

Table 5-3. Point cloud naming convention elements definition

Variable	Description	Identifier
C	Classification (compliant with the NSG Metadata Implementation Specification-Information Security Marking Requirements)	C= {U, S, TS, C}, with U = Unclassified, S = Secret, TS = Top Secret, C = Confidential
[_DIS]	Dissemination controls (compliant with the NSG Metadata Implementation Specification-Information Security Marking Requirements)	DIS = {FOU, DS, NF, REL_*}, with FOU = FOUO, DS = LIMDIS, NF = NOFORN; REL_ is followed by one or more valid GENC trigraph or CAPCO coalition tetragraph codes, *e.g.*: USA, FVEY, AUS, CAN, GBR, NZL, ISAF, KOR, etc.
_yyyy	Year of data collection; if multiple sources are used, this is the earliest source date	
mm	Month of data collection; if multiple sources are used, this is the earliest source date	mm = [01, 12]
dd	Day of data collection; if multiple sources are used, this is the earliest source date	dd = [01, 31]
DD	Latitude of SW corner of tile	if h = n: DD = [00, 89]; if h = s: DD = [01, 90]
MM	Minutes of latitude/longitude of SW corner	MM = [00, 59]
SS	Seconds of latitude/longitude of SW corner	SS = [00, 59]
h	Latitudinal hemisphere of SW corner of tile	h = {n, s} with n = North, s = South
DDD	Longitude of SW corner of tile	if e = e: DD = [000, 179]; if e = w: DD = [001, 180]
e	Longitudinal hemisphere of SW corner of tile	e = {e, w} with e = East, w = West
_MODAL	Sensor modality	MODAL = { LIDAR, EO, SAR, OTHER} Up to 5 alphanumeric characters describing the specific sensor modality used to create the point cloud
_PROGRAM	Program name	Up to 8 alphanumeric characters identifying the specific program name; if none exists, then 'OTHER'
_NPS	Nominal point spacing (equivalent to ground sample distance)	$\mathrm{NPS} = \sqrt{1/\mathrm{NPD}}$, with NPD = nominal point density in points/m^2
u	Unit of nominal point spacing	u = {m, cm} with m = meter, cm = centimeter; if NPS < 1 m (NPD > 1 pt/m^2), use cm
_VV	Version number	VV = [01, 99]
[.ext]	File format extension (for files only)	.ext = {.las, .laz, .bpf}

Additional detailed information on delivery, quality and description of product is provided within the metadata (XML) file; therefore, the file name need not duplicate this content. Information indicated in the file name must align with the information provided by the metadata. In case of any inconsistency, metadata information is authoritative. Therefore, applications accessing datasets shall utilize the metadata for file indexing.

Example file names are shown below. The names are for illustration only, as corresponding datasets do not exist.

- S_REL_FVEY _20170215_383811n901751w_LIDAR_OTHER_70cm_01.laz
- U_FOU_20110918_324332n643950e_LIDAR_BUCKEYE_50cm_01.las
- S_NF_20091105_045906n745741w_LIDAR_MACHETE_25cm_02.laz
- U_FOU_20160215_314432n1062341w_LIDAR_HALOE_10cm_02.bpf
- U_DS_20180304_330544n1060342w_SAR_OTHER_40cm_01.bpf
- U _20160723_384106n1270114e_EO_VRICON_50cm_01.las

6 Metadata

6.1 Introduction

The NEMIS specifies both a gridded and non-gridded (point cloud) elevation metadata content requirement and an XML-based exchange schema for use within the NSG that is compatible with existing software production environments, cloud computing systems, and NSG metadata standards.

Section 6.2 identifies types of metadata that are unique to point cloud data sets and whose exchange is not specifically addressed by the NEMIS metadata model.

Section 6.3 specifies the relationships between the NEMIS metadata model and related geospatial metadata models in use within the NSG, ASG, and/or by international partners.

Section 6.4 specifies the NEMIS logical model and its accompanying XSD-based specification.

Section 6.5 specifies conformance requirements that shall be satisfied when employing the NEMIS in XML-based data exchange.

6.2 Unique Point Cloud Metadata

6.2.1 Introduction

Non-gridded (point cloud) data sets may require, or be accompanied by, metadata which is not currently addressed by the NEMIS metadata model. The specification of such metadata and their accompanying exchange structures are unique to individual data formats. These formats and their accompanying guidance are specified in the following sections of this SIG.

6.2.2 Variable Length Records

The LAS format contains binary data consisting of a public header block, any number of (optional) Variable Length Records (VLRs) and various Point Data Records. Version 1.4 supports addition VLRs and adds any number of (optional) Extended Variable Length Records (EVLRs) at the end of the file. The VLRs contain variable types of data including projection information, metadata, waveform packets, and user application data. The EVLRs in LAS 1.4 have the advantage that they can be appended to the end of a LAS file. This allows adding, for example, projection information to a LAS file without having to rewrite the entire file. The VLRs were designed to support GeoTIFF metadata tags, such as projection information. However, they can also be used to support custom metadata supplied in XML format. For example, the GPM metadata are stored in VLRs within LAS files. Other essential point cloud metadata attributes should be stored in VLRs as well, even if they are also stored in an accompanying NEMIS-conformant XML instance document.

6.2.3 Bundled Files

The BPF format uses bundled files to store configuration files, GPM error metadata, and other metadata parameters. There is no limit to the number of bundled data files; however, all bundled files must fit within the File Header, which cannot exceed 2 GB. Each bundled file must be preceded by a bundled file header. There is no way of knowing how many bundled files are included in the BPF file, so after each bundled file header and its associate bundled file are read, the BPF file reader must interrogate the subsequent four bytes for the characters 'FILE'. If 'FILE' is not present, the reader should skip to the end of the file header and begin reading the point data. For more information on the storage of metadata in BPF bundled files, refer to NGA.SIG.0020_1.1_BPF.

6.2.4 Modality-specific Metadata

Some common metadata attributes reported for point cloud datasets are specific to the respective modality. Linear mode and Geiger mode LiDAR, in particular, have different metadata due to the unique ways in which the raw data are collected and processed. Some of these attributes are not yet supported by the NAS or, by extension, the NEMIS. Where possible, the additional metadata should be encoded into the data file header information as VLRs, bundled files, etc. This will ensure that the data are available to data consumers and software programs that process such modality-specific metadata.

The modality-specific metadata attributes are not mandatory and fall outside the scope of NEMIS XSD-based validation. However, it is suggested that they be provided in as much detail as possible for the benefit of downstream consumers who may use them to derive value-added products. Additional attributes not in this list may also be provided. See the USGS LiDAR Base Specification Version 1.4 for more information.

Table 6-1 lists the additional attributes recommended for linear mode LiDAR metadata.

Table 6-1. Additional linear mode LiDAR metadata attributes

Name	Description	Unit	Data Type
maxReturns	maximum number of returns per pulse		integer
pointSpacing	Nominal Point Spacing (NPS) of processed product	meter	float
pointDensity	Nominal Point Density (NPD) of processed product	points per square meter	float
flightHeight	nominal flight height above mean terrain for the collection	meter	integer
flightSpeed	nominal flight speed for the collection	meters/second	float
flightDirection	flight direction, as a compass azimuth	degree	integer
laserWavelength	central wavelength of the sensor laser	nanometer	integer
sensorScanAngle	sensor scan angle, total	degree	integer
scannerFrequency	scan frequency of the scanner	hertz	integer
scannerPulseRate	pulse rate of the scanner	kilohertz	integer
scannerPulseDuration	pulse duration of the scanner	nanosecond	integer
scannerPulseWidth	pulse width of the scanner	meter	float
beamDivergence	beam divergence	milliradian	float
swathWidth	nominal swath width on the ground	meter	integer
swathOverlap	nominal swath overlap (twice the sidelap)	percent	integer

Table 6-2 lists the additional attributes recommended for Geiger mode LiDAR metadata.

Table 6-2. Additional Geiger mode LiDAR metadata attributes

Name	Description	Unit	Data Type
pointSpacing	Nominal Point Spacing (NPS) of processed product	meters	float
pointDensity	Nominal Point Density (NPD) of processed product	points per square meter	float
flightHeight	nominal flight height above mean terrain for the collection	meters	integer
flightSpeed	nominal flight speed for the collection	meters/second	float
flightDirection	flight direction, as a compass azimuth	degrees	integer
laserWavelength	central wavelength of the sensor laser	nanometers	integer
instantaneousFieldOfView	instantaneous-field-of-view of a single pixel of the avalanche photodiode (APD) array	microradians	float
scannerPulseWidth	pulse width of the scanner	meters	float
scannerPulseRate	pulse rate of the scanner	kilohertz	integer
ScanMode	description of the scanning mechanism and pattern used for the collection	N/A	string
swathWidth	nominal swath width on the ground	meters	integer
swathOverlap	nominal swath overlap (twice the sidelap)	percent	integer

6.3 Related Geospatial Metadata Models

The NSG Application Schema (NGA.STND_0022_8.0_NAS) is the NSG-wide geospatial logical data model that specifies data representations meeting a wide range of data and metadata requirements. This range greatly exceeds the objectives of the NEMIS metadata model. International standard *ISO 19106:2004 Geographic information – Profiles* defines two classes of conformance, or profile types, for use when it is necessary to employ a base standard for a purpose that is narrower than that for which it was designed.

- A Class 1 profile is a pure subset of one or more base standards. A Class 1 profile does not allow for the relaxation of any restrictions specified in the base standards; for example, a mandatory element in a base standard may not be made optional in a Class 1 profile. In the case of an XSD-based realization of both the base standards and the profile, an XML instance document that validates against the profile XSD will also validate against the applicable set of base standard XSDs.
- A Class 2 profile allows both for the restriction of the base standards as well as non-conflicting extensions that fall outside the scope of the base standards, for example, adding a domain-unique information element. In the case of an XSD-based realization of both the base standards and the profile, an XML instance document that validates against the profile XSD will not necessarily validate against the applicable set of base standard XSDs.

The NEMIS metadata model meets the requirements of a Class 1 (pure subset) profile of the NAS. NEMIS-conformant XML instance documents will necessarily validate against the corresponding version of the NAS XSD-based realization.

The NEMIS metadata model also meets the minimum metadata requirements of the NSG Metadata Foundation (NGA.STND.0012_3.0_NMF) standard; Annex F documents the manner in which those requirements are met. As is the case for NEMIS, the NMF also meets the requirements of a Class 1 (pure subset) profile of the NAS.

The NAS adopts conceptual schemas from the International Organization for Standardization (ISO) 19100 series of standards, including ISO 19115 and ISO 19157, which govern the reporting of geographic information metadata and data quality, respectively. By integrating and employing these international conceptual schemas, NAS-conformant systems are more likely to be able to exchange geospatial data and metadata with international partners.

The NEMIS metadata model aligns closely with the Defense Gridded Elevation Data (DGED) implementation profile (DGIWG – 250), with which it shares many metadata requirements; however, it is the case that the accompanying XSD-based specifications differ in some details. DGED is based on the Elevation Surface Model (ESM) standard (DGIWG – 116-1), which derives from the Defence Metadata Foundation (DMF) version 2.0 (DGIWG – 114). The DMF metadata model adopts conceptual schemas from ISO 19115 and ISO 19157, so it shares many common classes, data types, and attributes with the NEMIS metadata model.

6.4 NEMIS Metadata Model

The NEMIS logical metadata model is specified using Unified Modeling Language (UML ISO/IEC 19505). Information elements are specified in terms of classes, their properties, and for each the allowed range of property values. Annex B, Annex C, Annex D, and Annex E collectively specify the NEMIS logical metadata model.

Annex A provides a UML primer to assist in reading UML class diagrams.

Annex B diagrammatically presents all NEMIS UML classes, properties, and property value ranges. To the greatest extent feasible, these are organized thematically so that all related aspects of the NEMIS metadata model are presented in a small set of class diagrams.

- Basic Types and Commonly Used Classes
- Citation and Responsible Party Information
- Constraint Information (including IC – Information Security Marking)
- Coordinate Reference Systems
- Distribution Information
- Extent Information (including Geography Markup Language)
- Identification Information (including NAS – Resource Metadata)
- Lineage Information (including Lineage Extensions)
- Maintenance Information
- Metadata Information (including NAS – Entity Metadata and Language-characterset Localisation Information)
- Spatial Representation Information
- Imagery Acquisition Information
- Data Quality (including Data Quality – Result and SWE Common)

Annex C tabularly presents in the form of a data dictionary the textual specification of each UML class, property, and property value range that appears in a UML class diagram in Annex B.

Annex D tabularly presents a textual specification of the UML property value ranges where there is a limited set of allowed values in the NEMIS metadata model.

Annex E specifies the quality attributes that shall be used to quantify the accuracy of elevation and point cloud data in NEMIS-conformant metadata XML instance documents.

Annex F describes the minimum mandatory metadata elements required by the NMF and maps them to the corresponding NEMIS schema locations.

The NEMIS logical metadata model is accompanied by an XSD-based specification for use in development and validation of XML instance documents. Its structure and use is specified in Annex G.

6.5 NEMIS-based Data Exchange

6.5.1 Introduction

The NEMIS logical metadata model is accompanied by an XSD-based specification for use in the development and validation of XML instance documents.

The NEMIS XSD is specified in accordance with the XML Schema Definition (XSD) 1.0, Second Edition, a recommendation of the World Wide Web Consortium (W3C) Recommendation XML Schema 1.0, Second Edition. While many tools are available to test validation of XML instance documents against corresponding XSD files, not all validation tools implement the full W3C XML Schema recommendation, and not all validation tools interpret the W3C XML Schema recommendation in the same manner. It is recommended that a tool with the strict interpretation of XML Schema and full support for *XML Schema 1.0* and *ISO/IEC 19757-3:2016 Information technology - Document Schema Definition Languages (DSDL) - Part 3: Rule-based validation - Schematron* should be used to ensure conformance of metadata instance documents.

6.5.2 Data Exchange Conformance Requirements

In order to achieve conformance to the structure and content of the NAS (and thus applicable aspects of GML (OGC 07-036r1) and the ISO 19100 series of geospatial standards), a Class 1 profile XSD must constrain, not extend, the corresponding data exchange schemas.

The NEMIS XSD imports schemas from applicable ISO namespaces and defines the required metadata entities (UML classes) and elements (UML attributes) in those namespaces as restrictions of the corresponding types in the base schemas. The resulting XSD has the following benefits:

1. Mandatory metadata properties required for validation are clearly identified.
2. Optional, accessory metadata properties are contained within a logical schema, allowing them to be recorded more consistently during input.
3. The schema is limited in scope relative to the base standards, making it easier to design XML instances for specific sets of gridded elevation or point cloud data.
4. Metadata recorded in accordance with ISO-compliant geographic XML schemas are easily translated to the NEMIS metadata schema, maximizing metadata retention from third party formats.
5. Geographic Information Systems (GIS), e.g., ArcGIS and QGIS, which are designed to support the ISO 19115-3 metadata encoding, have the ideal layout for displaying and editing NEMIS metadata.
6. Metadata limitations of the GeoTIFF header format, LAS VLR records, and other file formats are avoided by the requirement to provide all but format-unique metadata as XML instance documents.

Any elevation or point cloud metadata file that claims conformance to NEMIS shall satisfy all the metadata structure and content requirements specified in Annex B, Annex C, Annex D, and Annex E of this SIG. Minimum conformance requires that XML instance documents validate without error against the published NEMIS XML Schema and Schematron files.

Annex G.3 specifies procedures to be used to validate NMIS-conformant system interfaces and XML instance documents.

6.5.3 NEMIS Structure, Content, and Use

The NEMIS XSD-based schema is specified in terms of a set of XML Schema and Schematron files. These files are organized in accordance with the organization that governs them (*e.g.*, ISO or OGC), the specific standard that they support (*e.g.*, ISO 19115-1), the XML namespace that they define (*e.g.*, “cit”), and the version/edition of that XML namespace (*e.g.*, ‘2.0’).

For use in instance data validation, a complete set of local-use files is published as a self-contained archive that may be used without dependency on access to, and the availability of, network-based XML resources. The resulting technical artifact is published in the NSG Standards Registry. In that technical artifact all XML namespaces are resolved to local filesystem references, thus resulting in a standalone development and validation environment.

Furthermore, in order to maximize efficiency in metadata development and testing, this set of local-use files has been trimmed and edited to reflect exactly the requirements of the NEMIS. The resulting parsimonious set of files are a functional subset of those published by the respective authorities; in some cases a given XML namespace may only have a single XSD file whereas the authoritative source may employ a set of files to specify the full content of that XML namespace.

Annex G.4 specifies the structure and content of the NEMIS XML Schema and Schematron files in greater detail.

Although the overall NEMIS XML Schema is clearly specified in the UML class diagrams and data dictionary, there are several areas in which closer attention to nuances in the implementation of XML instance documents will be beneficial to the developer. These areas include:

- XLink and Internal References
- References to External Resources
- Text Locale

Annex G.5 specifies encoding guidelines in each of these areas.

Annex A UML Primer

A.1 UML Notations

The diagrams that appear in this document are presented using the Unified Modeling Language (UML) static structure diagram with the ISO Interface Definition Language (IDL) basic type definitions and the UML Object Constraint Language (OCL) as the conceptual schema language. The UML notations used in this SIG are described in Figure A-1.

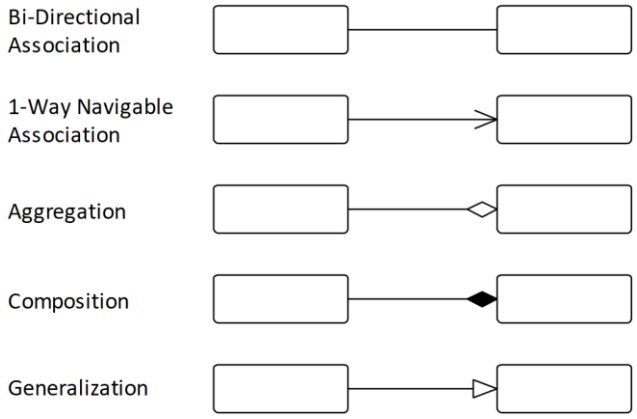

Figure A-1. UML notation

A.2 UML Model Relationships

A.3 Associations

An association is used to describe a relationship between two classes. UML defines three different types of relationships: association, aggregation, and composition. The three types have different semantics. An ordinary association shall be used to represent a general relationship between two classes. The aggregation and composition associations shall be used to create part-whole relationships between two classes. The direction of an association must be specified. If the direction is not specified, it is assumed to be a two-way association. If one-way associations are intended, the direction of the association is marked by an arrow at the end of the line.

An aggregation association is a relationship between two classes in which one of the classes plays the role of container and the other plays the role of a containee. A composition association is a strong aggregation. In a composition association, if a container object is deleted, then all of its containee objects are deleted as well. The composition association shall be used when the objects representing the parts of a container object cannot exist without the container object.

A.3.1 Generalization

A generalization is a relationship between a superclass and the subclasses that may be substituted for it. The superclass is the generalized class, while the subclasses are specialized classes (Figure A-).

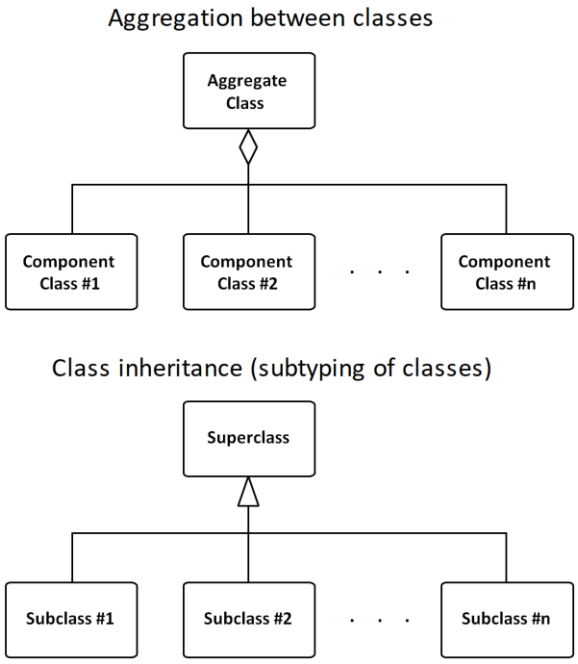

Figure A-2. UML aggregation and inheritance

A.4 UML Stereotypes

A UML stereotype is an extension mechanism for existing UML concepts. It is a model element that is used to classify (or mark) other UML elements so that they in some respect behave as if they were instances of new virtual or pseudo-metamodel classes whose form is based on existing base metamodel classes. Stereotypes augment the classification mechanisms on the basis of the built-in UML metamodel class hierarchy. Below are brief descriptions of the stereotypes used in this document.

In this document, the following stereotypes are used:

1. <<Type>> A class used for specification of a domain of instances (objects). A type may have attributes and associations. In the UML diagrams (Annex B) and data dictionary tables (Annex C), classes follow the <<Type>> stereotype unless specified otherwise.
2. <<DataType>> A type whose instances lack identity. Datatypes include primitive pre-defined types and user-definable types. Pre-defined types include numbers, character string, date, and time. User-definable types include enumerations and codelists.
3. <<Enumeration>> A data type whose instances are members of a list of named literal values.
4. <<CodeList>> A data type used to describe an incomplete (“open”) enumeration. Code lists are used to specify a list of named literal values that are managed outside of the scope of the model. If the elements of the list are completely known, an enumeration should be used; if only the likely values of the elements are known, a code list should be used.
5. <<Union>> A mutually exclusive selection of one of the specified attributes with its type.
6. <<Alternative>> A union where types may be specified without any accompanying attribute. In use, any of the specified types may be substituted for the <<Alternative>> type.

In addition, abstract classes, represented as “{abstract}” in the data dictionary tables, are classes that cannot be directly instantiated. The UML notation for this is to show the name in italics.

A.5 UML Roles

If an association is navigable in a particular direction, the model shall supply a “role name” that is appropriate for the role of the target object in relation to the source object. Thus in a two-way association, two role names will be supplied. Figure A-3 represents how role names and multiplicities are expressed in UML diagrams.

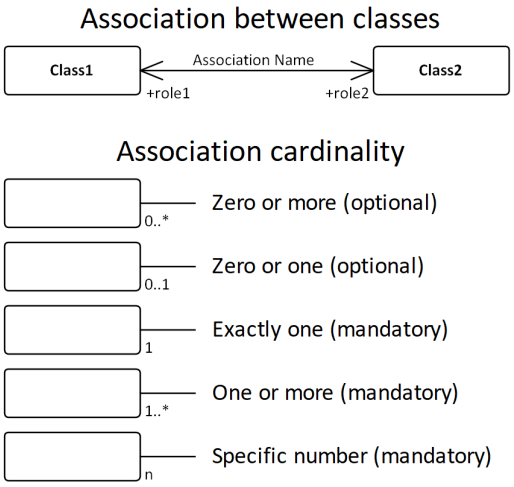

Figure A-3. UML role names and cardinality

A.6 Multiplicity

Multiplicity is a definition of an inclusive interval of non-negative integers to specify the allowable number of instances of described element.

Typical examples of multiplicity bounds include:

0	Collection must be empty
1	Exactly one instance
2	Exactly 2 instances
0..1	No instances or one instance
1..1	Exactly one instance
0..*	Zero or more instances
1..*	At least one instance
m..*n*	At least *m* but no more than *n* instances

Elements with multiplicities of 1, 2, and 1..* are mandatory unless specified otherwise by a co-constraint. Elements with multiplicities of 0..1 and 0..* are optional. If there is no multiplicity value associated with an attribute or role, its multiplicity is 1 (mandatory).

Annex B NEMIS UML Diagrams

B.1 Introduction

The NEMIS logical metadata model is specified using Unified Modeling Language (UML) ISO/IEC 19505. Information elements are specified in terms of UML classes (information modeling entities), their properties (*e.g.*, a property named “Length” whose range is represented using the data type “Real” and which may have the specific value “82.4”), and for each the allowed range of property values. This Annex diagrammatically presents all NEMIS UML classes, properties, and property value ranges. To the greatest extent feasible these are organized thematically so that most related aspects of the NEMIS metadata model are presented in a small set of class diagrams.

- Basic Types and Commonly Used Classes
- Citation and Responsible Party Information
- Constraint Information (including IC – Information Security Marking)
- Coordinate Reference Systems
- Distribution Information
- Extent Information (including Geography Markup Language)
- Identification Information (including NAS – Resource Metadata)
- Lineage Information (including Lineage Extensions)
- Maintenance Information
- Metadata Information (including NAS – Entity Metadata and Language-characterset Localisation Information)
- Spatial Representation Information
- Imagery Acquisition Information
- Data Quality (including Data Quality – Result and SWE Common)

The style of these UML diagrams follows that of the NSG Metadata Foundation (NGA.STND.0012_3.0_NMF), with three important exceptions:

1. The NEMIS logical metadata model is accompanied by an XSD-based specification for use in validation of XML instance documents and in some cases the naming of XSD elements and datatypes in external standards (e.g., the ISO 19100-series) differs from that used in the NAS (thus NMF) logical data model. Instead those names align with the content of the XSD-based encoding of the NMF, the NSG Metadata Implementation Specification (NGA.STND.0018_3.0_NMIS). All NEMIS data model diagrams follow the naming conventions established in the applicable XSD-based specifications; this enables a clear relationship to be established between the logical model elements and the physical implementation.

2. XSD-based implementations allow for a choice to be made between encoding the content of a UML attribute as the content of a directly corresponding XML element or, instead, as an XML attribute of the applicable XSD element. All NEMIS data model diagrams follow a naming convention of prepending a “@” symbol to the name of a logical element that is implemented as an XML attribute (e.g., “@srsName”); this enables a clear relationship to be established between the logical model elements and the physical implementation.

3. Due to pragmatic considerations that fall outside the scope of this SIG, it is sometimes the case that an implementation XSD may not structurally correspond to the logical model described in the NMF (e.g., Geography Markup Language, or IC Information Security markings). These sections of the UML class diagrams are enclosed in a dotted-line box and labeled “XML Schema Classes” as a reminder that the model reflects a specific physical implementation in XSD and not the logical model described in the NMF. The diagrammed model is functionally equivalent while enabling a clear relationship to be established between the logical model elements and the physical implementation.

UML package names are shown in the UML class diagrams where they precede class names, connected by a “**::**”. Each UML package has a corresponding XML namespace in the associated XSD; these XML namespaces are specified in Table G-1.

The corresponding Annex C tabularly presents in the form of a data dictionary the textual specification of each UML class, property, and property value range that appears in a UML class diagram. Annex D tabularly presents a textual specification of the UML property value ranges where there is a limited set of allowed values in the NEMIS.

B.2 UML Class Diagrams

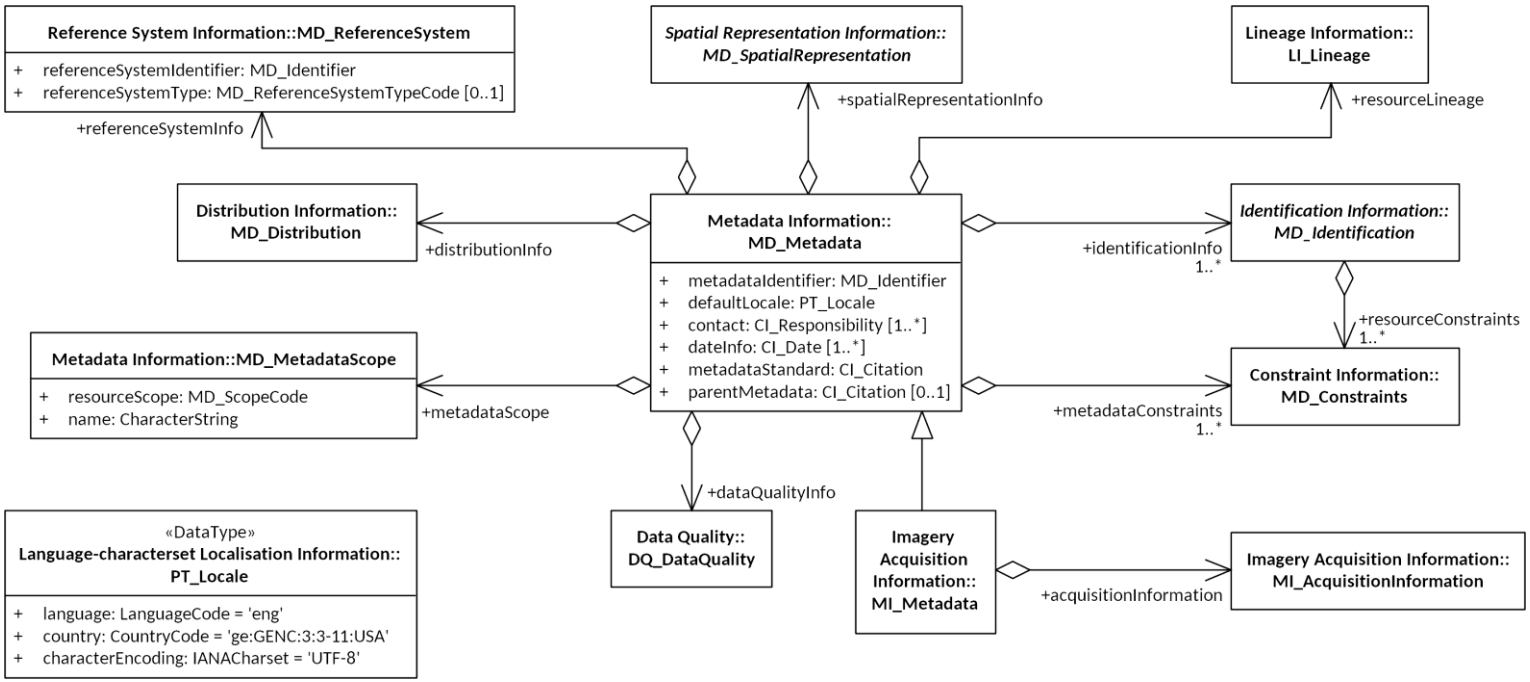

Figure B-1. Metadata Entity Set UML

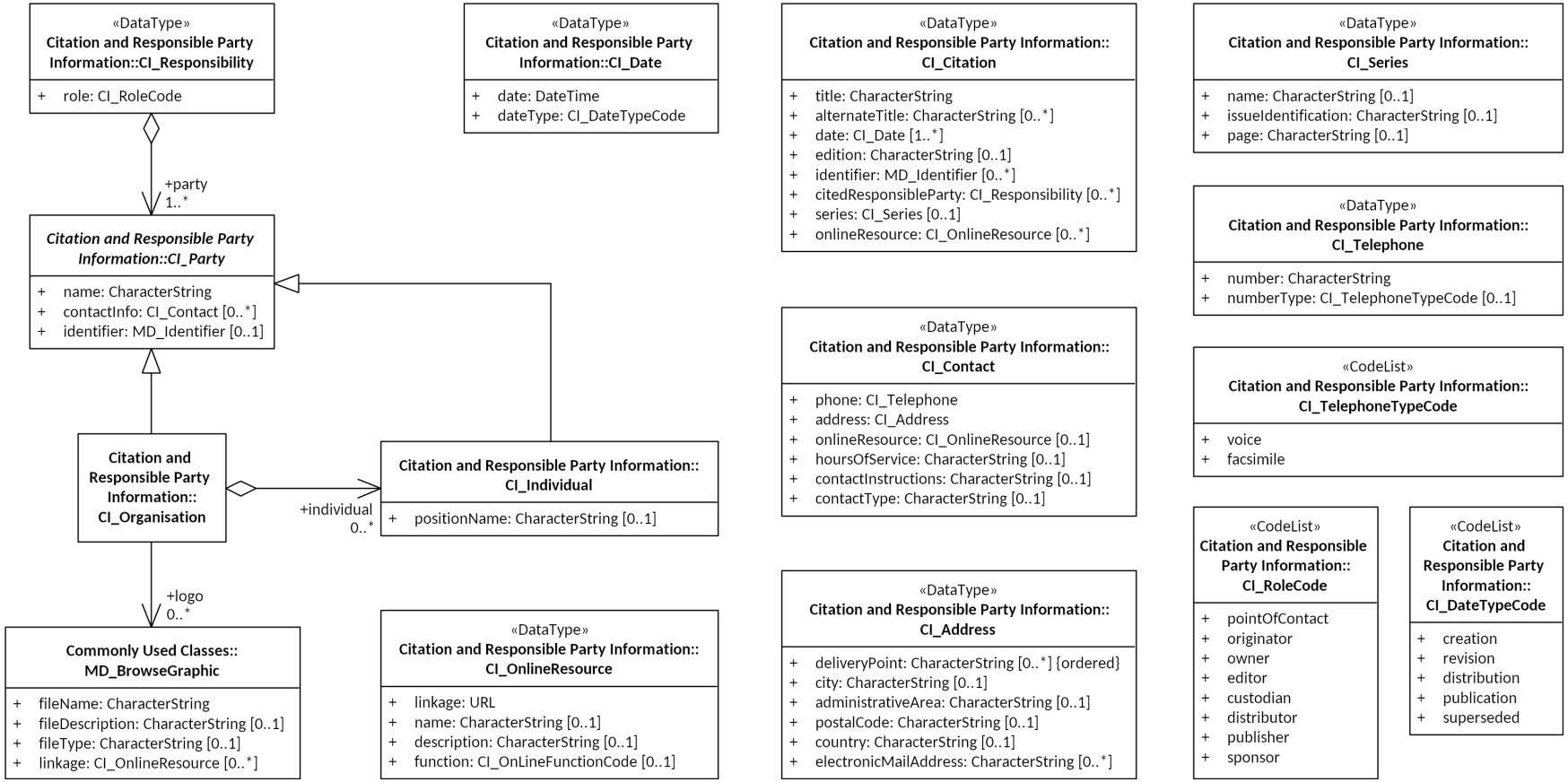

Figure B-2. Citation and Responsible Party UML

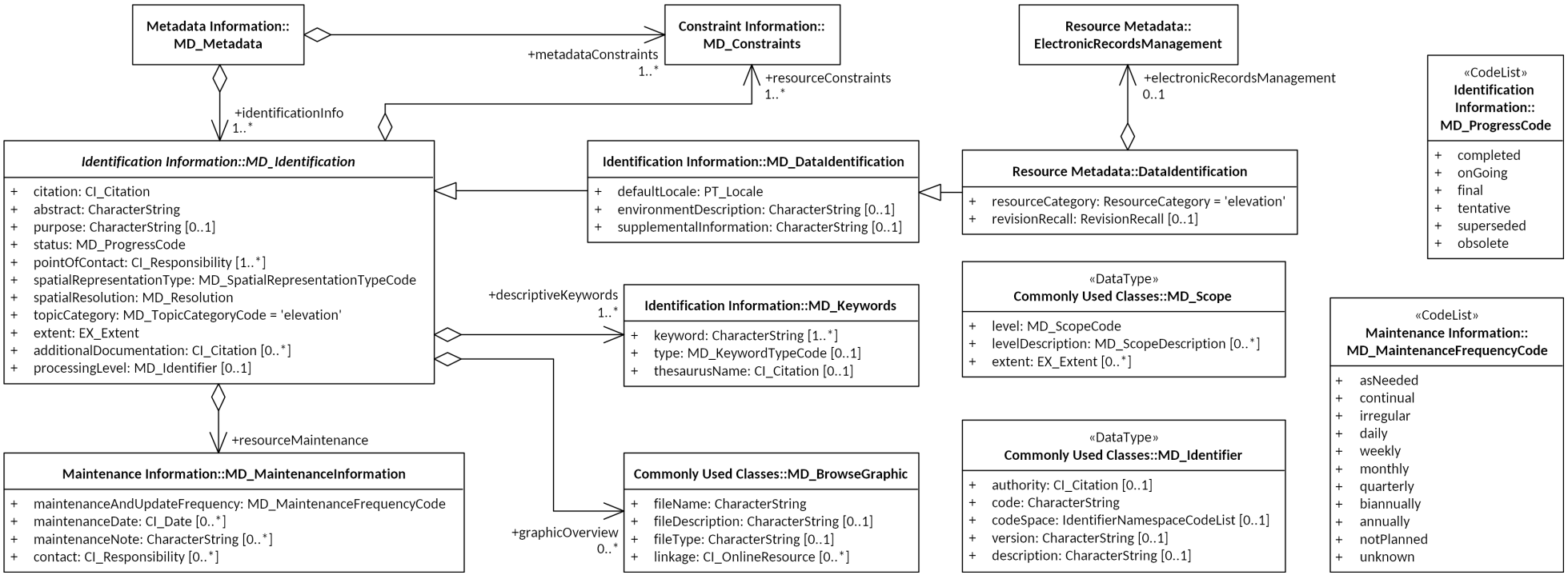

Figure B-3. Identification UML

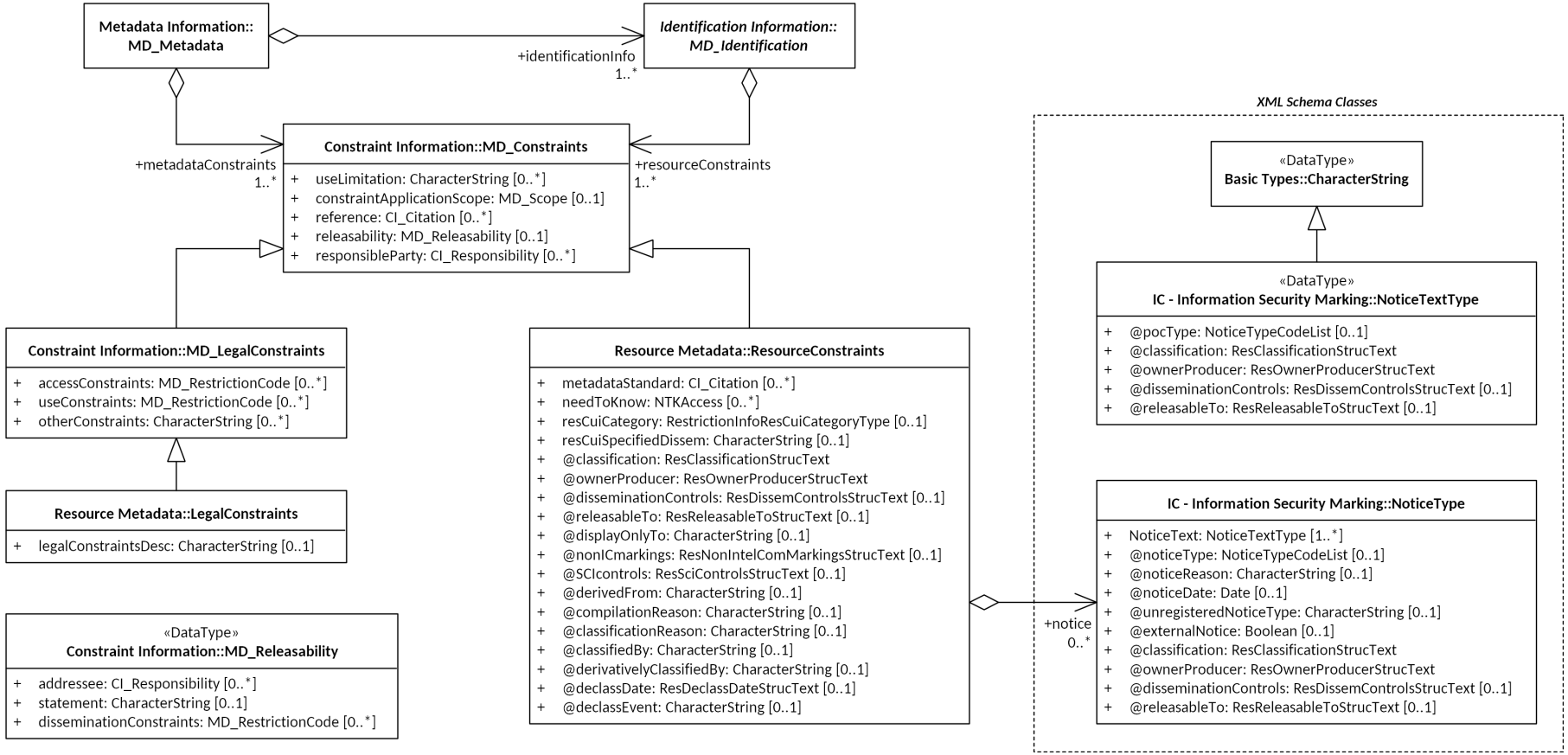

Figure B-4. Constraints UML

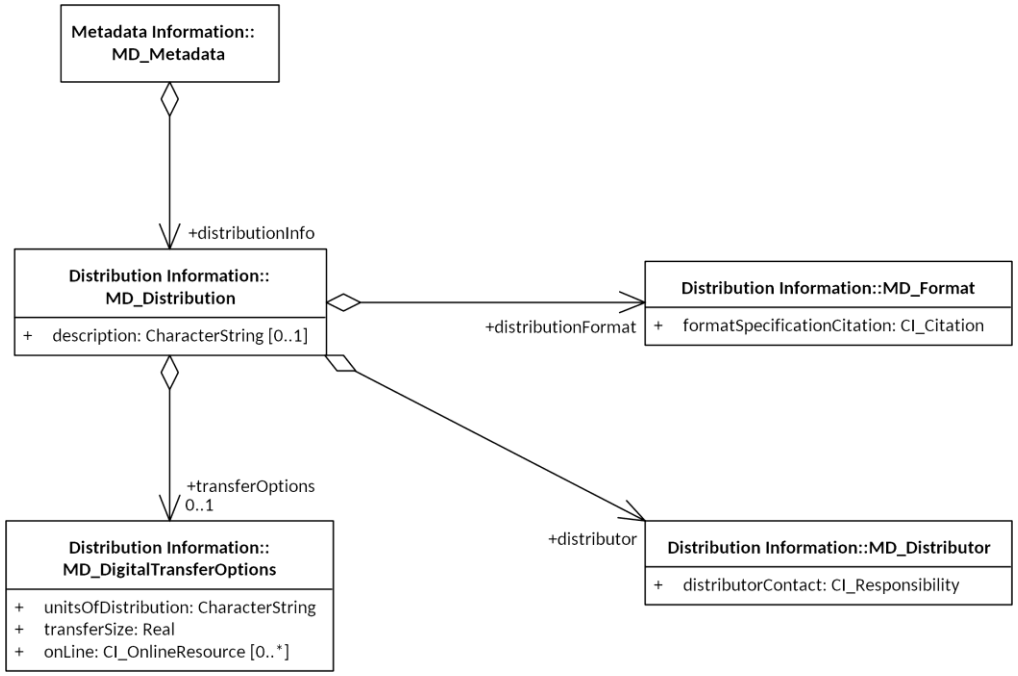

Figure B-5. Distribution UML

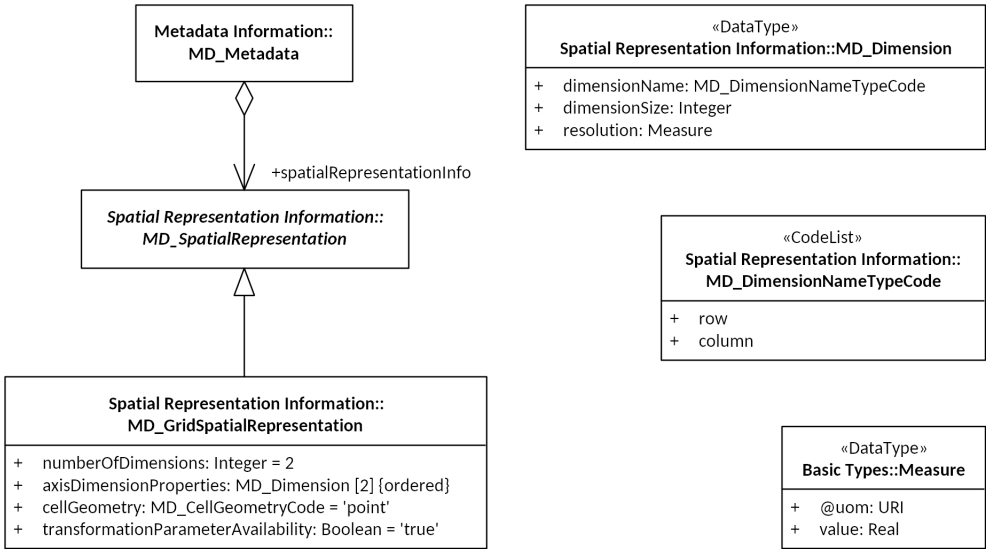

Figure B-6. Spatial Representation UML

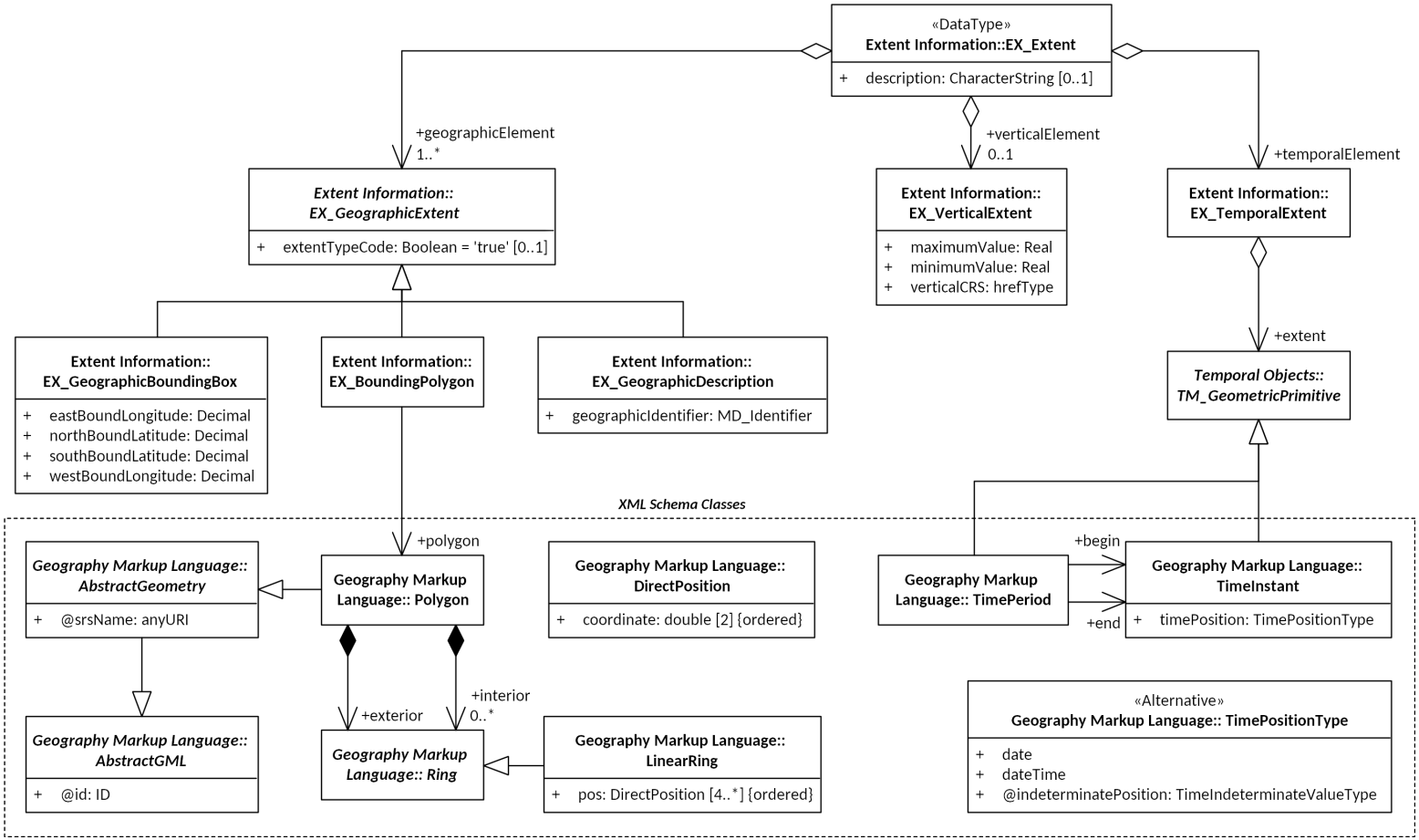

Figure B-7. Extent UML

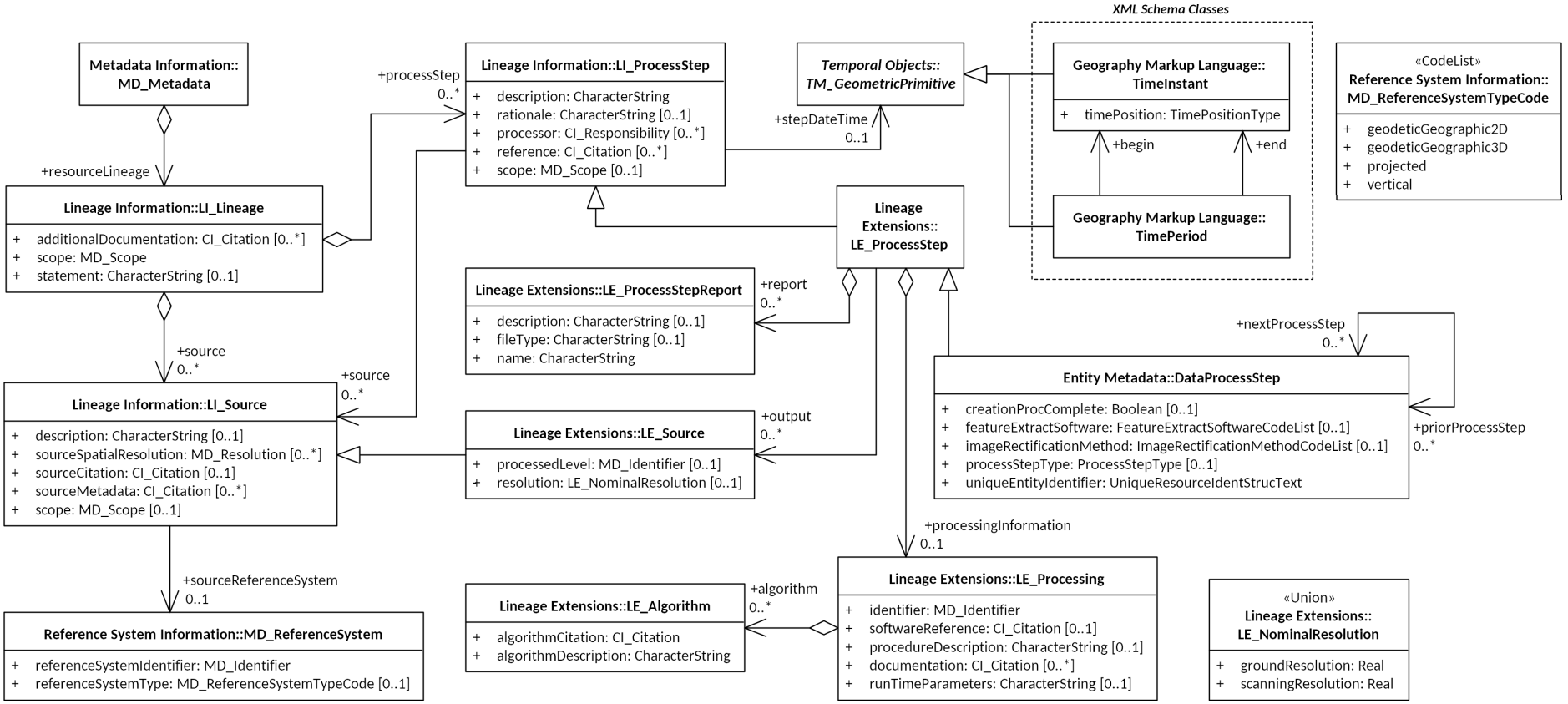

Figure B-8. Lineage UML

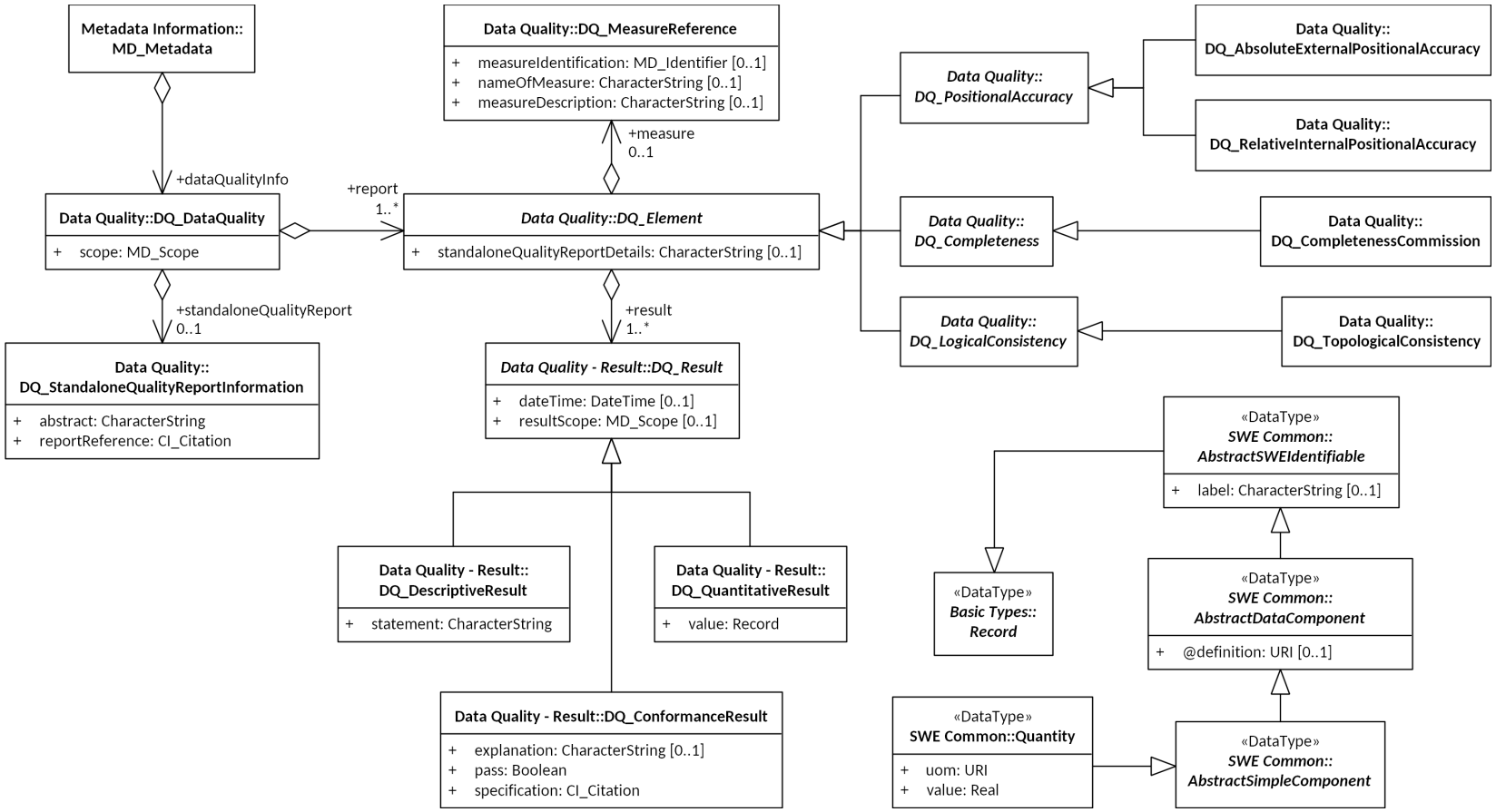

Figure B-9. Data Quality UML

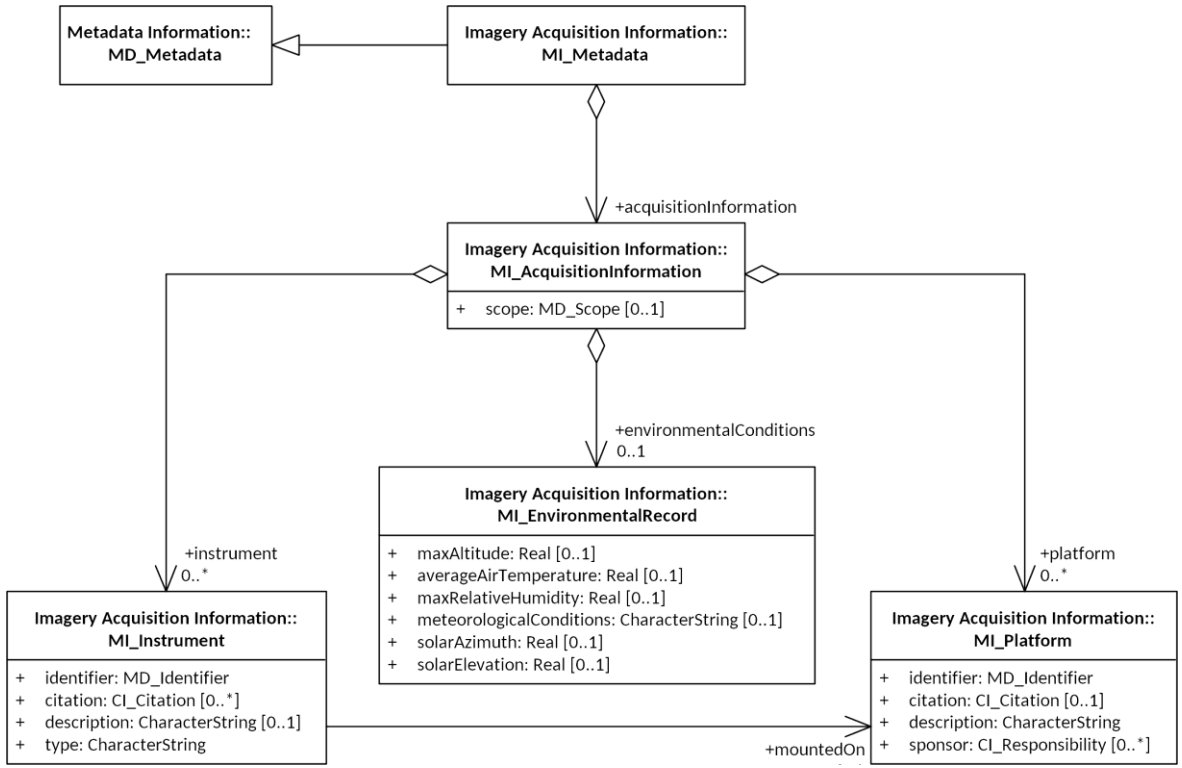

Figure B-10. Acquisition Information UML

Annex C NEMIS Data Dictionary

C.1 Introduction

The NEMIS logical metadata model is specified using Unified Modeling Language (UML) ISO/IEC 19505. Information elements are specified in terms of classes (information modeling entities), their properties (*e.g.*, a property named “Length” whose range is represented using the data type “Real” and which may have the specific value “82.4”), and for each the allowed range of property values. This Annex tabularly presents in the form of a data dictionary the textual specification of each UML class, property, and property value range that appears in a UML class diagram in Annex B.

The style of these tables follows that of the NSG Metadata Foundation (NGA.STND.0012_3.0_NMF), with two important exceptions:

1. The NEMIS logical metadata model is accompanied by an XSD-based specification for use in validation of XML instance documents and in some cases the naming of XSD elements and datatypes in external standards (*e.g.*, the ISO 19100-series) differs from that used in the NAS (thus NMF) logical data model. Instead, those names align with the content of the XSD-based encoding of the NMF, the NSG Metadata Implementation Specification (NGA.STND.0018_3.0_NMIS). All NEMIS data dictionary tables (and data model diagrams) follow the naming conventions established in the applicable XSD-based specifications; this enables a clear relationship to be established between the logical model elements and the physical implementation.

2. XSD-based implementations allow for a choice to be made between encoding the content of a UML attribute as the content of a directly corresponding XML element or instead as an XML attribute of the applicable XSD element. All NEMIS data dictionary tables (and data model diagrams) follow a naming convention of prepending a “@” symbol to the name of a logical element that is implemented as an XML attribute (*e.g.*, “@srsName”); this enables a clear relationship to be established between the logical model elements and the physical implementation.

The NEMIS data dictionary is organized as follows:

- Each UML class is documented by a unique table whose first row characterizes the class itself and whose remaining rows characterize its UML properties. To emphasize this distinction the row characterizing the class itself is presented with a light-gray fill.

- Each UML property for a given class is documented on a separate row. There are two types of UML properties: attributes, and association roles. All UML attributes are presented before UML association roles; the latter are distinguished by the indicator “Role” in the first column. Each subset of properties is ordered by the property name.

Each element in the NEMIS data dictionary is specified on the basis of a set of well-known characteristics; the set of characteristics will vary by the type of element. The information presented on each row is specified in Table C-1.

Table C-1. Data dictionary element definitions

Column	Purpose
XML Element	A textual value that is used to denote the class or property in data interchange. This corresponds to the XML element name specified by the NEMIS XSD, rather than the UML name in the NMF or NAS
Name	A compact and human-readable designator that is used to denote the class or property.
Definition	A precise statement of the nature, properties, scope, or essential qualities of the class or property.
Description	A statement of the nature, properties, scope, or non-essential qualities of the class or property that are not specified by the definition.
Multiplicity	(Properties only) A textual value specifying the number of discrete values that may be assigned to the property. For example; “1”, “0..1”, “0..*” or “1..*”, as in “Real [1..*]” to indicate that one or more Real values are required.
Type	A textual value that is used to denote either the parent classor in the case of a property its value range (datatype). These are named in accordance with class names (**XML Element** column) and therefore may not correspond to the UML name in the NMF or NAS.

Annex D tabularly presents a textual specification of the UML property value ranges (datatype) where there is a limited set of allowed values in the NEMIS metadata model.

C.2 Externally Specified Classes

The NEMIS metadata model employs a number of UML modeling classes that are documented by other, well-known standards and therefore do not need to be repeated here. Those externally referenced classes are as follows.

- **Encoding Types** – The following encoding types are used directly within the NEMIS; additional encoding types may be employed by other externally specified classes.
    - **anyURI**: a Uniform Resource Identifier (URI) reference. URIs are used to identify resources, and they may be absolute or relative.
    - **date**: indication of date expressed as a year, year-month, or year-month-day.
    - **dateTime**: indication of time expressed as a year, year-month, year-month-day, or year-month-day and time of day.
    - **double**: a double precision, 64-bit floating-point number.
    - **hrefType**: an XML Linking Language (XLink) datatype that supplies the data that allows an XLink application to find a remote resource (or resource fragment); it is a restriction of an **anyURI** as determined by *Legacy extended IRIs for XML resource identification* (2 November 2008) - W3C WG Note 3. The use of this datatype is fully documented in *XML Linking Language (XLink) Version 1.1* (6 May 2010) for the href XML Attribute.
    - **ID**: an XML Schema built-in derived datatype based on NCName (“non-colonized” Name) that is used by XML attributes to specify an identifier that is unique within an XML document, allowing the accompanying XML element to be referenced from elsewhere in that document. This type is fully documented in *XML Schema Part 2: Datatypes Second Edition* (28 October 2004).

- **Primitive Types** – Primitive types are fully documented in ISO 19103:2015. The following primitive types are used within NEMIS.
    - **Boolean**: a value representing binary logic. The value can be either true or false.
    - **CharacterString**: an arbitrary-length sequence of characters, including accents and special characters from the repertoire of one of the adopted character sets.
    - **Decimal**: a decimal data type in which the number represents an exact value, as a finite representation of a decimal number.
    - **Integer**: a signed integral number. The representation of an integer is encapsulation- and usage-dependent.
    - **Real**: a signed real (floating point) number consisting of a mantissa and an exponent. The representation of a Real is encapsulation- and usage-dependent.
- **Date and DateTime Information**
    - **Date**: gives values for year, month, and day. Character encoding of a Date is a string which shall follow the format for date specified by ISO 8601. This class is fully documented in ISO 19103:2015.

      NOTE The precision of the date can be defined by showing a combination of century plus year plus month plus day, *e.g.* YY (century), YYYY (year), YYYY-MM (year-month), or YYYY-MM-DD (year-month-day).
    - **DateTime**: combination of a date and a time type (given by an hour, minute, and second). Examples include: 2000-02-29T00:00:00Z, 2014-07-08T00:00:00Z, 2016-07-01T09:30:47Z, 2019-02-13T15:37:56Z, etc. Character encoding of a DateTime shall follow ISO 8601. This class is fully documented in ISO 19103:2015.
- **IC Data Encoding Specifications (DES)**
    - **NTKAccess**: A specification of metadata that enables the determination of whether a requester (for example: a person or a service) can be granted access to an information resource, as determined by IC DES.NTK.XML.V10 (2013).
    - **RevisionRecall**: Information regarding notification of withdrawal or modification of a data resource, as determined by IC DES.RevRecall.XML.V1 (2014).
- **Electronic Records Management**
    - **ElectronicRecordsManagement**: Information used by a records management system to manage a resource. This type is fully documented in NGA.STND.0018_3.0 and NGA.STND.0012_3.0_NMF.

C.3 Basic Types

C.3.1 Measure

XML Element / Name	Definition	Description	Multiplicity	Type
Measure Measure (ISO TC211)	The result from performing the act or process of ascertaining the value of a characteristic of some entity, as determined by ISO 19103:2015.	For example, a graphic could portray a legend, a security marking, or a data provider logo.		<<DataType>>
@uom Measure Unit of Measure	The standard quantity of measurement in which a measure value is expressed.	The “uom” URI shall be a valid unit of measure specified in reference to “http://api.nsgreg.nga.mil/physical-quantity”, such as “http://api.nsgreg.nga.mil/physical-quantity/length/metre”.	1	<<DataType>> URI
Value Measure Value	The value of a measure.		1	<<DataType>> Real

C.4 Commonly Used Classes

C.4.1 MD_BrowseGraphic

XML Element / Name	Definition	Description	Multiplicity	Type
MD_BrowseGraphic Browse Graphic (ISO TC211)	A graphic image that illustrates some aspect of the resource, as determined by ISO 19115-1:2014.	For example, a graphic could portray a legend, a security marking, or a data provider logo.		
filename Graphic File Name	The name of a file that contains a graphic that provides an illustration of an aspect of a resource.		1	<<DataType>> CharacterString
fileDescription Graphic File Description	A text description of the illustration contained in a graphic file.		0..1	<<DataType>> CharacterString
filetype Graphic File Type	The electronic file format in which an illustration is encoded in a graphic file.	For example: EPS, GIF, JPEG, PBM, PS, TIFF, and PDF.	0..1	<<DataType>> CharacterString
linkage Graphic Linkage	A link or internet address of an online source from which a graphic file may be accessed and/or retrieved.		0..*	<<DataType>> CI_OnlineResource (Annex C.5.6)

C.4.2 MD_Identifier

XML Element / Name	Definition	Description	Multiplicity	Type
MD_Identifier Identifier (ISO TC211)	A value uniquely identifying an object within a namespace, as determined by ISO 19115-1:2014.			<<DataType>>

XML Element / Name	Definition	Description	Multiplicity	Type
authority Namespace Authority	The person or party responsible for maintenance of the namespace.		1	<<DataType>> CI_Citation (Annex C.5.2)
code Code	An alphanumeric value (a 'code') identifying an instance in the namespace.	For example, for the codespace of 'EPSG' the code value '4326'.	1	<<DataType>> CharacterString
codeSpace Codespace	The identifier of the namespace in which a code is valid.		0..1	<<CodeList>> IdentifierNamespaceCodeList (Annex D.12.1)
description Code Description	A natural language description of the meaning of a code value.	For example, for the codespace of 'EPSG' with the code value '4326' the description "WGS-84".	0..1	<<DataType>> CharacterString
version Codespace Version	The version identifier for a namespace.		0..1	<<DataType>> CharacterString

C.4.3 MD_Scope

XML Element / Name	Definition	Description	Multiplicity	Type
MD_Scope Scope (ISO TC211)	The content restrictions and the horizontal, vertical, and/or temporal limits of a resource, as determined by ISO 19115-1:2014.	For example, a limit on a resource can result in information being reported only for feature types or within a specified geographic region.		<<DataType>>
level Scope Level	A denotation, according to content-type, of a subset of a resource.	For example: a subset restricted to all feature instances, a subset restricted to documents, or a subset consisting of data represented as coverages.	1	<<CodeList>> MD_ScopeCode (Annex D.2.1)
levelDescription Scope Description	A detailed account of the information represented by the scope category.	A scope category is a type of information used to identify a subset of the content of a resource. An example of a scope category is a subset restricted to all feature instances. A description of this scope category identifies the specific feature instances in the subset.	0..*	<<Union>> MD_ScopeDescription (Annex C.4.4)
extent Scope Spatio-temporal Extent	The horizontal, vertical, and/or temporal limit(s) used as criteria for identifying a subset of a resource.	A horizontal limit defines a geographic bounding box or polygon, which limits the geographic content to data with geographic coordinates that overlap the bounding box or polygon. A vertical limit specifies the highest and lowest geospatial boundary. For example, a vertical limit for a dataset containing the height of buildings limits the scope to data associated with buildings based on height. A temporal limit specifies a time period. For example, a temporal limit of January 13, 2009 to November 7, 2012 limits the scope of a dataset containing many years of emails to only those emails sent during the specified time period.	0..*	<<DataType>> EX_Extent (Annex C.9.2)

C.4.4 MD_ScopeDescription

XML Element / Name	Definition	Description	Multiplicity	Type
MD_ScopeDescription Scope Description (ISO TC211)	The class of information (for example: feature types) that is described by information associated with a scope, as determined by ISO 19115-1:2014.	(ISO) description of the class of information covered by the information.		<<Union>>
attributes Scoped Attribute Types	A specification of one or more instances of attribute types that are included within a scope.	A scope specifies a subset within a collection of information (for example: the content of a resource).	1..*	<<DataType>> CharacterString
features Scoped Feature Types	A specification of one or more instances of feature types that are included within a scope.	A scope specifies a subset within a collection of information (for example: the content of a resource).	1..*	<<DataType>> CharacterString
featureInstances Scoped Feature Instances	A specification of one or more feature instances that are included within a scope.	A scope specifies a subset within a collection of information (for example: the content of a resource).	1..*	<<DataType>> CharacterString
attributeInstances Scoped Attribute Instances	A specification of one or more attribute instances that are included within a scope.	A scope specifies a subset within a collection of information (for example: the content of a resource).	1..*	<<DataType>> CharacterString
dataset Scoped Dataset	A dataset that is included within a scope.	A scope specifies a subset within a collection of information (for example: the content of a resource).	1	<<DataType>> CharacterString
other Scoped Other Category	A class of information that does not fall into another scope categories, but is included within a scope.	A scope specifies a subset within a collection of information (for example: the content of a resource).	1	<<DataType>> CharacterString

C.5 Citation and Responsible Party Information

C.5.1 CI_Address

XML Element / Name	Definition	Description	Multiplicity	Type
CI_Address Citation Address (ISO TC211)	Addressing information that enables contact with a party, as determined by ISO 19115-1:2014.	Examples of a party are an individual or an organisation.		<<DataType>>
deliveryPoint Postal Address Delivery Point	The address line component of a postal address.		0..*	<<DataType>> CharacterString
city Postal Address City	The city component of a postal (physical mailing) address.		0..1	<<DataType>> CharacterString
administrativeArea Postal Address Administrative Subdivision	The administrative subdivision component of a postal (physical mailing) address.	Examples of administrative subdivisions include a province or a state.	0..1	<<DataType>> CharacterString

XML Element / Name	Definition	Description	Multiplicity	Type
postalCode Postal Code	The postal code component of a postal (physical mailing) address.	An example of a postal code is the United States ZIP code.	0..1	<<DataType>> CharacterString
country Postal Address Country	The country component of a postal (physical mailing) address.		0..1	<<DataType>> CharacterString
electronicMailAddress Electronic Mail Address	The address of an electronic mailbox of a responsible individual, organisation or position.		0..*	<<DataType>> CharacterString

C.5.2 CI_Citation

XML Element / Name	Definition	Description	Multiplicity	Type
CI_Citation Citation (ISO TC211)	A specification of a cited resource, as determined by ISO 19115-1:2014.			<<DataType>>
title Resource Title	A name by which a resource is known.	The resource title must be specified.	1	<<DataType>> CharacterString
alternateTitle Resource Alternate Title	A short name, or other language name, by which a resource is known.	For example, 'DCW' as an alternative title for 'Digital Chart of the World'.	0..*	<<DataType>> CharacterString
date Cited Resource Date	A reference date and, optionally, time for a cited resource.		1..*	<<DataType>> CI_Date (Annex C.5.4)
edition Resource Edition	The version or edition of a resource.		0..1	<<DataType>> CharacterString
identifier Resource Identifier	A value uniquely identifying a resource within a namespace.		0..*	<<DataType>> MD_Identifier (Annex C.4.2)
citedResponsibleParty Cited Resource Responsible Party	The name and/or position information for person(s) and/or organisation(s) responsible for the resource.	This includes the role, name, contact, and/or position information about the party.	0..*	<<DataType>> CI_Responsibility (Annex C.5.9)
series Resource Series Information	Information about a series, or aggregate resource, of which the resource is a part.		0..*	<<DataType>> CI_Series (Annex C.5.10)

XML Element / Name	Definition	Description	Multiplicity	Type
onlineResource Resource Online Reference	Information about network sources from which a resource can be obtained.	Information regarding a resource may include, for example, its content (a dataset), a specification of its structure or content, or a specification of a community metadata profile regarding its structure or content.	0..*	<<DataType>> CI_OnlineResource (Annex C.5.6)

C.5.3 CI_Contact

XML Element / Name	Definition	Description	Multiplicity	Type
CI_Contact Responsible Contact (ISO TC211)	Information required to enable contact with the responsible person and/or organisation, as determined by ISO 19115-1:2014.			<<DataType>>
phone Contact Telephone Number	A telephone number by which a cited party may be contacted.		1	<<DataType>> CI_Telephone (Annex C.5.10)
address Contact Address	An address (for example: postal or electronic) by which a cited party may be contacted.		1	<<DataType>> CI_Address (Annex C.5.1)
onlineResource Contact Online Resource	Information about an internet resource by which a cited party may be contacted.		0..1	<<DataType>> CI_OnlineResource (Annex C.5.6)
hoursofService Contact Hours of Service	A time period (including time zone) during which a cited party may be contacted.		0..1	<<DataType>> CharacterString
contactInstructions Contact Instructions	Supplemental instructions on how or when to contact a person and/or organisation.		0..1	<<DataType>> CharacterString
contactType Contact Type	A description of the role of the contact.	For example, “sales representative” or “Team lead for the project”.	0..1	<<DataType>> CharacterString

C.5.4 CI_Date

XML Element / Name	Definition	Description	Multiplicity	Type
CI_Date Date and Type (ISO TC211)	A reference date and an event type used to describe it, as determined by ISO 19115-1:2014.			<<DataType>>
date Resource Reference Date	A reference date (and optionally time) for a resource.	The reference date is formatted in accordance with ISO 8601.	1	<<DataType>> DateTime

XML Element / Name	Definition	Description	Multiplicity	Type
dateType Date Type	The type of event to which a date is referenced.		1	<<CodeList>> CI_DateTypeCode (Annex D.3.1)

C.5.5 CI_Individual

XML Element / Name	Definition	Description	Multiplicity	Type
CI_Individual Resource Party Individual (ISO TC211)	Information about an individual, including the individual's name and position, as determined by ISO 19115-1:2014.			Subclass of {abstract} CI_Party (Annex C.5.8)
positionName Position Name	The title of an individual in an organization.	For example, Chief Engineer or Midwest Sales Manager.	0..1	<<DataType>> CharacterString

C.5.6 CI_OnlineResource

XML Element / Name	Definition	Description	Multiplicity	Type
CI_OnlineResource Online Resource (ISO TC211)	Information about online sources from which the dataset, specification, or community profile name and extended metadata elements can be obtained, as determined by ISO 19115-1:2014.			<<DataType>>
linkage Resource Online Linkage	A network location of a resource specified using a Uniform Resource Locator (URL) or Uniform Resource Identifier (URI) address, or similar addressing scheme.	For example: "http://www.statkart.no/isotc211"	1	<<DataType>> URL
name Online Resource Name	The name of the online resource.		0..1	<<DataType>> CharacterString
description Online Resource Description	A detailed text description of what the online resource is and/or does.		0..1	<<DataType>> CharacterString
function Online Resource Function	The function performed by the online resource.	Examples include search, order, and download.	0..1	<<CodeList>> CI_OnLineFunctionCode (Annex D.3.2)

C.5.7 CI_Organisation

XML Element / Name	Definition	Description	Multiplicity	Type
CI_Organisation Resource Party Organisation (ISO TC211)	Information about an organisation, including its logo and members of the organisation, as determined by ISO 19115-1:2014.			Subclass of {abstract} CI_Party (Annex C.5.8)

XML Element / Name	Definition	Description	Multiplicity	Type
Role: individual Organisation Individual	A member of the organisation.		0..*	CI_Individual (Annex C.5.5)
Role: logo Organisation Logo	A graphic image that identifies an organisation.	This graphic is usually a representation or symbol of an organisation's name or trademark, and is often designed for recognition and branding.	0..*	MD_BrowseGraphic (Annex C.4.1)

C.5.8 CI_Party

XML Element / Name	Definition	Description	Multiplicity	Type
CI_Party Resource Party (ISO TC211)	Information about an individual or an organisation associated with a resource, as determined by ISO 19115-1:2014.			{abstract}
name Resource Party Name	The name of an individual or organisation associated with a resource.		1	<<DataType>> CharacterString
contactInformation Party Contact Information	Information that enables communication with a person, organisation, and/or position within an organisation who is associated with a resource.	Contact information may include, for example, a phone number for the person, organisation, or position associated with a specific resource.	0..*	<<DataType>> CI_Contact (Annex C.5.3)

C.5.9 CI_Responsibility

XML Element / Name	Definition	Description	Multiplicity	Type
CI_Responsibility Responsibility (ISO TC211)	Information about a role of responsibility with respect to a resource and the party(ies) that serve in that capacity, as determined by ISO 19115-1:2014.	A party is an individual and/or organisation who serves in a role of responsibility with respect to a resource.		<<DataType>>
role Responsibility Role	The function performed by a responsible party with respect to a resource.		1	<<CodeList>> CI_RoleCode (Annex D.3.3)
Role: respParty Responsibility Party	Information about party(ies) who are serving in a role of responsibility with respect to a resource.		1..*	CI_Party (Annex C.5.8)

C.5.10 CI_Series

XML Element / Name	Definition	Description	Multiplicity	Type
CI_Series Series Specification (ISO TC211)	Information about the series, or aggregate resource, of which a resource is a component, as determined by ISO 19115-1:2014.			<<DataType>>
name Resource Series Name	The name of either a series of resources or an aggregate resource, of which a resource is a member.	For example, the name of a published journal.	0..1	<<DataType>> CharacterString
issueIdentification Series Member Identification	Information identifying either a member of a series of resources or a component of an aggregate resource.	For example, a particular issue of a published journal.	0..1	<<DataType>> CharacterString
page Series Member Component Identification	In the case of a complex series component, information identifying a specific subcomponent.	For example, a set of pages for a journal article that was published in a particular issue of a journal.	0..1	<<DataType>> CharacterString

C.5.11 CI_Telephone

XML Element / Name	Definition	Description	Multiplicity	Type
CI_Telephone Telephone Number (ISO TC211)	A telephone number for contacting a responsible person and/or organisation, as determined by ISO 19115-1:2014.			<<DataType>>
number Telephone Number	A number that is assigned to a particular telephone or group of telephones and used in making connections to it.		1	<<DataType>> CharacterString
numberType Telephone Number Type	The name of a telephone communication mode.	Examples include voice or facsimile.	0..1	<<CodeList>> CI_TelephoneTypeCode (Annex D.3.4)

C.6 Constraint Information

C.6.1 MD_Constraints

XML Element / Name	Definition	Description	Multiplicity	Type
MD_Constraints Resource Constraints (ISO TC211)	Restrictions on the access to and/or use of a resource or a set of resource metadata, as determined by ISO 19115-1:2014.	A resource may consist of either a collection of data or the metadata that describes some collection of data.		
constraintApplicationScope Constraint Application Scope	The content level restriction and/or spatio-temporal extent limitation of a restriction on the access to and/or use of a resource or resource metadata.		0..1	<<DataType>> MD_Scope (Annex C.4.3)

XML Element / Name	Definition	Description	Multiplicity	Type
reference Resource Constraint Reference	Citation information for detailed information about the constraint.	For example, a citation of a copyright statement or licence agreement. A resource constraint is a restriction on the access to and/or use of a resource or a set of resource metadata.	0..*	<<DataType>> CI_Citation (Annex C.5.2)
releasability Resource Releasability Constraint	Information concerning a party to whom access to and/or use of a resource, or a set of resource metadata, should be either specifically allowed or specifically disallowed.		0..1	<<DataType>> MD_Releasability (Annex C.6.3)
responsibleParty Resource Constraint Responsible Party	A party acting in a role of responsibility for a constraint.	A resource constraint is a restriction on the access to and/or use of a resource or a set of resource metadata.	0..*	<<DataType>> CI_Responsibility (Annex C.5.9)
useLimitation Resource Use Limitation	A limitation affecting the fitness for use of the resource or a set of resource metadata for a specific use or application.	For example: “Not to be used for navigation.” And “Not to be used for targeting.”	0..*	<<DataType>> CharacterString

C.6.2 MD_LegalConstraints

XML Element / Name	Definition	Description	Multiplicity	Type
MD_LegalConstraints Legal Constraints (ISO TC211)	A specification of restrictions and/or legal prerequisites for accessing and/or using either a resource or metadata about a resource, as determined by ISO 19115-1:2014.			Subclass of MD_Constraints (Annex C.6.1)
accessConstraints Resource Access Constraint	A legal constraint regarding access to the resource or a set of resource metadata.	Access constraints are applied, for example, to assure the protection of privacy or intellectual property.	0..*	<<CodeList>> MD_RestrictionCode (Annex D.4.1)
otherConstraints Other Resource Constraints	An additional constraint regarding access to and/or use of resource or a set of resource metadata.	Use restrictions may include limitations and warnings.	0..*	<<DataType>> CharacterString
useConstraints Resource Use Constraint	A legal constraint regarding the use of a resource or a set of resource metadata.	Use restrictions may include limitations and warnings.	0..*	<<CodeList>> MD_RestrictionCode (Annex D.4.1)

C.6.3 MD_Releasability

XML Element / Name	Definition	Description	Multiplicity	Type
MD_Releasability Releasability Constraint (ISO TC211)	A specification of the party(ies) to whom access to and/or use of a resource, or a set of resource metadata, should be either specifically allowed or specifically disallowed, as determined by ISO 19115-1:2014.			<<DataType>>

XML Element / Name	Definition	Description	Multiplicity	Type
addressee Constraint Addressee	A party to which the release statement applies.		0..*	<<DataType>> CI_Responsibility (Annex C.5.9)
disseminationConstraints Dissemination Constraint	A category of limitation placed upon the access to, or use of, the resource or a set of resource metadata.		0..*	<<CodeList>> MD_RestrictionCode (Annex D.4.1)
statement Release Statement	A statement that identifies specific allowances or specific disallowances for access to the resource or a set of resource metadata.		0..1	<<DataType>> CharacterString

C.7 Coordinate Reference Systems

C.7.1 SC_CRS

XML Element / Name	Definition	Description	Multiplicity	Type
SC_CRS Coordinate Reference System (ISO TC211)	A Coordinate Reference System (CRS), which is a coordinate system that is related to an object by a datum, as determined by ISO 19111:2007.	It is usually single but may be compound (using at least two independent coordinate reference systems).		{abstract} Subclass of {abstract} IO_IdentifiedObjectBase (from ISO 19111:2007) (Annex D.8.1)
scope Scope	A description of the usage, or limitations of usage, for which this Coordinate Reference System (CRS) is valid.		1..*	<<DataType>> CharacterString

C.7.2 SC_SingleCRS

XML Element / Name	Definition	Description	Multiplicity	Type
SC_SingleCRS Single Coordinate Reference System (ISO TC211)	A coordinate reference system (CRS) consisting of one coordinate system and one datum (as opposed to a Compound CRS), as determined by ISO 19111:2007.	In ISO 19111:2003, this class was called SC_CoordinateReferenceSystem.		{abstract} Subclass of {abstract} SC_CRS (Annex C.7.1)

C.7.3 SC_VerticalCRS

XML Element / Name	Definition	Description	Multiplicity	Type
SC_VerticalCRS Vertical Coordinate Reference System (ISO TC211)	A 1D coordinate reference system (CRS) used for recording heights or depths, as determined by ISO 19111:2007.	Vertical CRSs make use of the direction of gravity to define the concept of height or depth, but the relationship with gravity may not be straightforward. By implication, ellipsoidal heights (h) cannot be captured in a vertical coordinate reference system. Ellipsoidal heights cannot exist independently, but only as inseparable part of a 3D coordinate tuple defined in a geodetic 3D coordinate reference system.		Subclass of {abstract} SC_SingleCRS (Annex C.7.2)

C.8 Distribution Information

C.8.1 MD_DigitalTransferOptions

XML Element / Name	Definition	Description	Multiplicity	Type
MD_DigitalTransferOptions Digital Transfer Options (ISO TC211)	The technical means and media by which the resource may be obtained from a distributor, as determined by ISO 19115-1:2014.			
unitsOfDistribution Data Source Units of Distribution	A description of the type of units in which the resource is available for distribution.		1	<<DataType>> CI_OnlineResource (Annex C.5.6)
transferSize Data Transfer Size	The estimated size of a content distribution unit in a specified distribution format, expressed in megabytes.		1	<<DataType>> Real
onLine Data Source Online Information	Information about an online source from which the resource may be obtained.		0..*	<<DataType>> CI_OnlineResource (Annex C.5.6)

C.8.2 MD_Distribution

XML Element / Name	Definition	Description	Multiplicity	Type
MD_Distribution Data Distribution (ISO TC211)	Information about the mechanisms available for obtaining the resource, as determined by ISO 19115-1:2014.			
description Data Distribution Description	A brief textual description of a set of distribution options for obtaining the resource.		0..1	<<DataType>> CharacterString
Role: distributionFormat Data Distribution Format	Information about a format in which the resource may be distributed.		1	MD_Format (Annex C.8.4)

XML Element / Name	Definition	Description	Multiplicity	Type
Role: distributor Data Distributor	Information about a distributor of the resource.		1	MD_Distributor (Annex C.8.3)
Role: transferOptions Data Transfer Options	Information about technical means and media by which the resource may be obtained from a distributor.		0..1	MD_DigitalTransferOptions (Annex C.8.1)

C.8.3 MD_Distributor

XML Element / Name	Definition	Description	Multiplicity	Type
MD_Distributor Data Distributor (ISO TC211)	Information about a party from whom the resource may be obtained, as determined by ISO 19115-1:2014.			
distributorContact Resource Distributor Contact	The party acting in a role of responsibility for the distribution of the resource.		1	<<DataType>> CI_Responsibility (Annex C.5.9)

C.8.4 MD_Format

XML Element / Name	Definition	Description	Multiplicity	Type
MD_Format Data Format (ISO TC211)	A description of the computer language construct that specifies the representation of data objects in a record, file, message, storage device or transmission channel, as determined by ISO 19115-1:2014.			
formatSpecificationCitation Data Format Specification Citation	Citation information for a subset, profile, or product specification of the data transfer format in which the resource is available.		1	<<DataType>> CI_Citation (Annex C.5.2)

C.9 Extent Information

C.9.1 EX_BoundingPolygon

XML Element / Name	Definition	Description	Multiplicity	Type
EX_BoundingPolygon Geographic Bounding Object (ISO TC211)	An enclosing geometric object which locates the resource, as determined by ISO 19115-1:2014.	The boundary of the geometric object is expressed as a set of (x,y) coordinate(s).		Subclass of {abstract} EX_GeographicExtent (Annex C.9.5)

XML Element / Name	Definition	Description	Multiplicity	Type
Role: polygon Bounding Geometric Object	The geometric object whose boundaries define the extent of the resource.	Examples of a bounding object are a point and a polygon.	1	Polygon (Annex C.10.3)

C.9.2 EX_Extent

XML Element / Name	Definition	Description	Multiplicity	Type
EX_Extent Resource Extent (ISO TC211)	Information about the spatial, vertical, and/or temporal coverage of a resource, as determined by ISO 19115-1:2014.	A spatial extent is an area(s), such as a point(s), line(s), and/or polygon(s). A vertical extent is a height or depth, or a range of them. A temporal extent is one or more periods in time. Granularity and precision are variable. The extents characterize the time(s) and location(s) of the content of the resource.		<<DataType>>
description Resource Extent Description	A textual description of the spatial, temporal, and/or vertical coverage of a resource.		0..1	<<DataType>> CharacterString
Role: geographicElement Spatial Extent	A spatial component of the extent(s) of a resource.	The geographic extent is a geographic identifier (for example: a country name), a bounding box (for example: the bounding latitutes and longitudes), or a bounding object (for example: a set of coordinate points).	1..*	EX_GeographicExtent (Annex C.9.5)
Role: temporalElement Temporal Extent	A temporal component of the extent(s) of a resource.	The temporal extent is the time period covered by a resource.	1	EX_TemporalExtent (Annex C.9.6)
Role: verticalElement Vertical Extent	A vertical component of the extent(s) of a resource.	The vertical extent is the minimum and maximum vertical limits present in the vertical domain of the resource.	0..1	EX_VerticalExtent (Annex C.9.7)

C.9.3 EX_GeographicBoundingBox

XML Element / Name	Definition	Description	Multiplicity	Type
EX_GeographicBoundingBox Geographic Bounding Box (ISO TC211)	A geographic extent of the resource, as determined by ISO 19115-1:2014.	A geographic bounding box is an approximate reference. Therefore, the bounding box may be provided with a precision of up to two decimal places, and a specification of the coordinate reference system is unnecessary.		Subclass of {abstract} EX_GeographicExtent (Annex C.9.5)
eastBoundLongitude Eastern Bounding Longitude	The eastern-most coordinate of the limit of a resource extent, expressed in longitude in decimal degrees (positive east).		1	<<DataType>> Decimal

XML Element / Name	Definition	Description	Multiplicity	Type
northBoundLatitude Northern Bounding Latitude	The northern-most coordinate of the limit of a resource extent, expressed in latitude in decimal degrees (positive north).		1	<<DataType>> Decimal
southBoundLatitude Southern Bounding Latitude	The southern-most coordinate of the limit of a resource extent, expressed in latitude in decimal degrees (positive north).		1	<<DataType>> Decimal
westBoundLongitude Western Bounding Longitude	The western-most coordinate of the limit of a resource extent, expressed in longitude in decimal degrees (positive east).		1	<<DataType>> Decimal

C.9.4 EX_GeographicDescription

XML Element / Name	Definition	Description	Multiplicity	Type
EX_GeographicDescription Geographic Description (ISO TC211)	A description of the geographic area which is denoted by geographic identifiers, as determined by ISO 19115-1:2014.			Subclass of {abstract} EX_GeographicExtent (Annex C.9.5)
geographicIdentifier Geographic Identifier	A unique identifier used to denote a geographic area.	The geographic identifier should be formulated in accordance with *ISO 19112 Geographic information – Spatial referencing by geographic identifiers*.	1	<<DataType>> MD_Identifier (Annex C.4.2)

C.9.5 EX_GeographicExtent

XML Element / Name	Definition	Description	Multiplicity	Type
EX_GeographicExtent Geographic Extent (ISO TC211)	A spatial extent of the resource, as determined by ISO 19115-1:2014.	The geographic extent is a geographic identifier (for example: a country name), a bounding box (for example: the bounding latitudes and longitudes), or a bounding object (for example: a set of coordinate points).		{abstract}
extentTypeCode Extent Type	An indication of whether the specified geographic extent encompasses an area covered by the data (‘true’) or an area where data is not present (‘false’).	When encoded numerically, 0 = exclusion (or ‘False’) and 1 = inclusion (or ‘True’).	0..1	Boolean Value = ‘true’

C.9.6 EX_TemporalExtent

XML Element / Name	Definition	Description	Multiplicity	Type
EX_TemporalExtent Temporal Extent (ISO TC211)	The time period covered by the resource, as determined by ISO 19115-1:2014.			

XML Element / Name	Definition	Description	Multiplicity	Type
Role: extent Temporal Extent	The temporal limit of the resource, expressed as an instantaneous point in time or a period of time.		1	TM_GeometricPrimitive (Annex C.19.1)

C.9.7 EX_VerticalExtent

XML Element / Name	Definition	Description	Multiplicity	Type
EX_VerticalExtent Vertical Extent (ISO TC211)	The vertical extent of the resource, as determined by ISO 19115-1:2014.	The vertical extent is the minimum and maximum vertical limits present in the vertical domain of the resource.		
maximumValue Vertical Extent Maximum Value	The highest vertical limit of a geospatial extent.		1	<<DataType>> Real
minimumValue Vertical Extent Minimum Value	The lowest vertical limit of a geospatial extent.		1	<<DataType>> Real
verticalCRS Coordinate Reference System of Vertical Extent	Information about the vertical Coordinate Reference System (CRS) in which the maximum and minimum elevation values are measured.	The CRS identification specifies the unit of measure.	1	<<DataType>> hrefType

C.10 Geography Markup Language

C.10.1 AbstractGML

XML Element / Name	Definition	Description	Multiplicity	Type
AbstractGML Abstract GML Object	The abstract element gml:AbstractGML is "any GML object having identity". It acts as the head of an XML Schema substitution group, which may include any element which is a GML feature, or other object, with identity. This is used as a variable in content models in GML core and application schemas. It is effectively an abstract superclass for all GML objects.			{abstract}
id ID	The attribute gml:id supports provision of a handle for the XML element representing a GML Object. Its use is mandatory for all GML objects. It is of XML type ID, so is constrained to be unique in the XML document within which it occurs.		1	ID

C.10.2 AbstractGeometry

XML Element / Name	Definition	Description	Multiplicity	Type
AbstractGeometry Abstract Geometry	The AbstractGeometry element is the abstract head of the substitution group for all geometry elements of GML. This includes pre-defined and user-defined geometry elements. Any geometry element shall be a direct or indirect extension/restriction of AbstractGeometryType and shall be directly or indirectly in the substitution group of AbstractGeometry.			{abstract} Subclass of {abstract} AbstractGML (Annex C.10.1)
srsName SRS Name	The attribute gml:srsName references a Coordinate Reference System (CRS), which is a coordinate system that is related to an object by a datum, as determined by ISO 19111:2007.		1	anyURI

C.10.3 Polygon

XML Element / Name	Definition	Description	Multiplicity	Type
Polygon Polygon	A gml:Polygon is a special surface that is defined by a single surface patch. The boundary of this patch is coplanar and the polygon uses planar interpolation in its interior.			Subclass of {abstract} AbstractGeometry (Annex C.10.2)
Role: exterior Exterior	A boundary of a surface consists of a number of rings. In the normal 2D case, one of these rings is distinguished as being the exterior boundary. In a general manifold this is not always possible, in which case all boundaries shall be listed as interior boundaries, and the exterior will be empty.		1	AbstractRing (Annex C.10.4)
Role: interior Interior	A boundary of a surface consists of a number of rings. The "interior" rings separate the surface / surface patch from the area enclosed by the rings.		0..*	AbstractRing (Annex C.10.4)

C.10.4 AbstractRing

XML Element / Name	Definition	Description	Multiplicity	Type
AbstractRing Abstract Ring	A closed sequence of positions that delineate a one-dimensional boundary on a two-dimensional surface.			{abstract}

C.10.5 LinearRing

XML Element / Name	Definition	Description	Multiplicity	Type
LinearRing Linear Ring	A gml:LinearRing is a gml:Ring defined by four or more coordinate positions, with linear interpolation between them; the first and last positions must be coincident.			Subclass of {abstract} AbstractRing (Annex C.10.4)
pos Directly Determined Position	A gml:DirectPosition instance specifies the coordinates for a position within some coordinate reference system (CRS).		4..* {ordered}	DirectPosition (Annex C.10.6)

C.10.6 DirectPosition

XML Element / Name	Definition	Description	Multiplicity	Type
DirectPosition Direct Position	Specifies the coordinates for a position within some coordinate reference system (CRS).			<<DataType>>
coordinate Coordinate	A sequence of numbers that specify the coordinate of a position in a specified reference system.		2 {ordered}	<<DataType>> Real

C.10.7 TimePositionType

XML Element / Name	Definition	Description	Multiplicity	Type
TimePositionType Temporal Position Type	Direct representation of a temporal position. Indeterminate time values are also allowed, as described in ISO 19108.	The method for identifying a temporal position is specific to each temporal reference system. gml:TimePositionType supports the description of temporal position according to the subtypes described in ISO 19108. In common with many of the components modelled as data types in the ISO 19100 series of International Standards, the corresponding GML component has simple content.		<<Alternative>>
date Date Position	A value specifying year, month and day.	Character encoding of a gml:date is a string which shall follow the format for date specified by ISO 8601. A full date is formatted as YYYYMMDD or YYYY-MM-DD.	0..1 Conditional / `dateTime` not populated?	date
dateTime Date and Time Position	A combination of a date and a time type (given by an hour, minute and second).	Character encoding of a gml:dateTime shall follow ISO 8601. Combined dates and times should be formatted as YYYYMMDDThh:mm:ss, YYYYMMDDThhmmss, or YYYY-MM-DDThh:mm:ss. These representations include no TimeZone indicator, so they are assumed to be local time. YYYYMMDDThh:mm:ssZ would indicate universal time.	0..1 Conditional / `date` not populated?	dateTime
@indeterminatePosition Indeterminate Position Type	An inexact or unknown temporal position.	Inexact temporal positions may be expressed using the optional gml:indeterminatePosition attribute. This takes a value from an enumeration. The gml:indeterminatePosition attribute can be used alone or it can qualify a specific value for temporal position (*e.g.*, before 2015-07-20, after 2018-03-12T13:08:56Z).	0..1	TimeIndeterminateValueType (Annex C.10.10)

C.10.8 TimeInstant

XML Element / Name	Definition	Description	Multiplicity	Type
TimeInstant Temporal Instant	A zero-dimensional temporal geometry primitive that represents a position in time, as determined by ISO 19108:2002/Cor.1:2006.	It is equivalent to a point in space. In practice, an instant is an interval whose duration is less than the resolution of the time scale.		Subclass of {abstract} TM_GeometricPrimitive
timePosition Temporal Position	The temporal position of a gml:TimeInstant.		1	<<DataType>> TimePositionType Annex C.10.7)

C.10.9 TimePeriod

XML Element / Name	Definition	Description	Multiplicity	Type
TimePeriod Temporal Period	A one-dimensional temporal geometry primitive that represents an extent in time, as determined by ISO 19108:2002/Cor.1:2006.	The period is equivalent to a curve in space. Like a curve, it is an open interval bounded by beginning and end points (instants), and has length (duration). Its location in time is described by the temporal positions of the instants at which it begins and ends; its duration equals the temporal distance between those two temporal positions.		Subclass of {abstract} TM_GeometricPrimitive
Role: begin Begin Temporal Instant	The gml:TimeInstant that starts this gml:TimePeriod.	The temporal position of the gml:TimeInstant designated by the value of 'begin' may be indeterminate.	1	<<DataType>> TimeInstant (Annex C.10.8)
Role: end End Temporal Instant	The gml:TimeInstant that ends this gml:TimePeriod.	The temporal position of the gml:TimeInstant designated by the value of 'end' may be indeterminate.	1	<<DataType>> TimeInstant (Annex C.10.8)

C.10.10 TimeIndeterminateValueType

XML Element / Name	Definition	Description	Type
TimeIndetermiateValueType Indeterminate Temporal Position Type	A qualifier to the specific value for a temporal position, as determined by ISO 19108:2002/Cor.1:2006.		<<Enumeration>>
after After	Indicates that the actual temporal position is unknown, but it is known to be after the specified value.		
before Before	Indicates that the actual temporal position is unknown, but it is known to be before the specified value.		
now Now	Indicates that the specified value shall be replaced with the current temporal position whenever the value is accessed.		

XML Element / Name	Definition	Description	Type
unknown Unknown	Indicates that no specific value for temporal position is provided.		

C.11 Identification Information

C.11.1 MD_DataIdentification

XML Element / Name	Definition	Description	Multiplicity	Type
MD_DataIdentification Data Identification (ISO TC211)	Information that uniquely identifies a data resource, as determined by ISO 19115-1:2014.			Subclass of {abstract} MD_Identification (Annex C.11.2)
defaultLocale Text Locale	The cultural and linguistic setting applicable to the interpretation of a character string.	Specified by a combination of language, potentially a country, and a character encoding (character set).	1	<<DataType>> PT_Locale (Annex C.12.1)
environmentDescription Resource Environment Description	Details about the how the data resource appears in the production environment.	The description may include details such as the software, the computer operating system, the file name, and the dataset size.	0..1	<<DataType>> CharacterString
supplementalInformation Resource Supplemental Information	Additional information that describes the data resource in some way that is not already specified by existing metadata.		0..1	<<DataType>> CharacterString

C.11.2 MD_Identification

XML Element / Name	Definition	Description	Multiplicity	Type
MD_Identification Resource Identification (ISO TC211)	Distinguishing information that uniquely identifies resource, as determined by ISO 19115-1:2014.	Facts about a resource include citation, unique identification, usage, maintenance, format, constraints, and keywords information.		{abstract}
abstract Resource Abstract	A brief statement or narrative summary of the resource.		1	<<DataType>> CharacterString
additionalDocumentation Additional Resource Documentation	A standardized reference for additional documentation associated with a resource.	For example, citing related articles, publications, user guides, or data dictionaries.	0..*	<<DataType>> CI_Citation (Annex C.5.2)

XML Element / Name	Definition	Description	Multiplicity	Type
citation Resource Citation	A standardized reference for a resource.		1	<<DataType>> CI_Citation (Annex C.5.2)
pointOfContact Resource Point of Contact	A party acting in a role of responsibility for a resource.		1..*	<<DataType>> CI_Responsibility (Annex C.5.9)
processingLevel Processing Level	A unique identifier that specifies the level of processing of a resource in accordance with a coding system used by the producer of that resource.	For example, “Level 1B” as determined by the U.S. National Oceanic and Atmospheric Administration (NOAA).	0..1	<<DataType>> MD_Identifier (Annex C.4.2)
purpose Resource Purpose	A summary of the intentions with which the resource was developed.	For example: “This dataset was produced to document the damage caused by Hurricane Sandy.”	0..1	<<DataType>> CharacterString
extent Resource Extent	The horizontal, vertical, and/or temporal coverage of the content of a resource.		1	<<DataType>> EX_Extent (Annex C.9.2)
spatialRepresentationType Resource Spatial Representation Type	The method used to represent the spatial information in a resource.	For example: “vector”, “grid”, and “video”.	1	<<CodeList>> MD_SpatialRepresentationTypeCode (Annex D.5.3)
spatialResolution Resource Spatial Resolution	A numeric factor that provides a general understanding of the density of spatial data in a resource or describes the range of resolutions in which a resource may be used.		1	<<Union>> MD_Resolution (Annex C.11.5)
status Resource Status	The lifecycle state of the resource.	For example: “completed”, “planned”, and “obsolete”.	1	<<CodeList>> MD_ProgressCode (Annex D.5.2)
topicCategory Topic Category	A theme or topic keyword that represents a subject of the resource.		1	<<Enumeration>> MD_TopicCategoryCode = ‘elevation’ (Annex D.5.4)
Role: descriptiveKeywords Descriptive Keywords	Information about keywords describing this resource.		1..*	MD_Keywords (Annex C.11.3)
Role: graphicOverview Graphic Overview	Information about graphic image(s) that illustrate some aspect of a resource.	For example, information about a graphic portraying a legend, a security marking, or a data provider logo.	1..*	MD_BrowseGraphic (Annex C.4.1)

XML Element / Name	Definition	Description	Multiplicity	Type
Role: resourceConstraints Resource Constraints Information	Information about restrictions on the access to and/or use of this resource.		1..*	MD_Constraints (Annex C.6.1)
Role: resourceMaintenance Resource Maintenance Information	Information about the scope and frequency of updates to a resource.	Scope in this context refers to content type restriction and/or spatio-temporal extent limitation.	1	MD_MaintenanceInformation (Annex C.15.1)

C.11.3 MD_Keywords

XML Element / Name	Definition	Description	Multiplicity	Type
MD_Keywords Keywords (ISO TC211)	A list of words or phrases describing a resource, and their context, as determined by ISO 19115-1:2014.			
keyword Resource Keyword	A common-use or formalised word or phrase that indicates the content of a resource.		1..*	<<DataType>> CharacterString
type Keyword Type	The category that is used to group similar keywords.	For example: place, stratum, and temporal.	0..1	<<CodeList>> MD_KeywordTypeCode (Annex D.5.1)
thesaurusName Thesaurus Name	Citation information for a formally registered thesaurus or a similar authoritative source of keywords.	The thesaurus specifies a collection of instances from some ontology, but is not an ontology. It might be a list of places that include rivers, mountains, counties, and cities. There might be a Laconte county, the city of Laconte, the Laconte River, and Mt. Laconte; when searching it is useful for the user to be able to restrict the search to only rivers.	0..1	<<DataType>> CI_Citation (Annex C.5.2)

C.11.4 MD_RepresentativeFraction

XML Element / Name	Definition	Description	Multiplicity	Type
MD_RepresentativeFraction Representative Fraction (ISO TC 211)	A unitless ratio of one quantity to another, expressed in fractional form, as determined by ISO 19115-1:2014.			<<DataType>>
denominator Fraction Denominator	The number below the line in a vulgar fraction.		1	<<DataType>> Integer

C.11.5 MD_Resolution

XML Element / Name	Definition	Description	Multiplicity	Type
MD_Resolution Data Resolution (ISO TC211)	The level of detail of a collection of data, expressed as a scale factor, a distance, or an angle, as determined by ISO 19115-1:2014.			<<Union>>
equivalentScale Resolution Equivalent Scale	The level of detail of a collection of data expressed as the scale of a comparable hardcopy map or chart.		1	<<DataType>> MD_RepresentativeFraction (Annex C.11.4)
distance Resolution Distance	The level of detail of a collection of data expressed as a horizontal ground sample distance.		1	<<DataType>> Real
vertical Vertical Sampling Distance	The level of detail a collection of data expressed as a vertical sampling distance.		1	<<DataType>> Real
angularDistance Angular Distance	The level of detail of a collection of data, expressed as an angular sampling measure.		1	<<DataType>> Real
levelDetail Level of Spatial Detail	A brief textual description of the spatial resolution of a resource.		1	<<DataType>> CharacterString

C.12 Language-characterset Localisation Information

C.12.1 PT_Locale

XML Element / Name	Definition	Description	Multiplicity	Type
PT_Locale Text Locale (ISO TC211)	The locale with respect to which a localized character string is expressed, as determined by ISO 19115-1:2014.	Specified by a combination of language, potentially a country, and a character encoding (character set).		<<DataType>>
language Text Locale Language	A designation of the locale language of a textual value.		1	<<CodeList>> LanguageCode Value = ‘eng’ (Annex D.6.1)
country Text Locale Country	A designation of the specific country of the locale language of a textual value.		1	<<CodeList>> CountryCode Value = ‘ge:GENC:3:3-11:USA’ (Annex D.6.2)

XML Element / Name	Definition	Description	Multiplicity	Type
characterEncoding Text Locale Character Encoding	A designation of the character set to be used to encode the textual value of the locale.		1	<<CodeList>> IANACharset Value = 'UTF-8' (Annex D.6.3)

C.13 Lineage Information

C.13.1 LI_Lineage

XML Element / Name	Definition	Description	Multiplicity	Type
LI_Lineage Resource Lineage (ISO TC211)	Information about the sources and/or production processes used in creating the resource, as determined by ISO 19115-1:2014.			
additionalDocumentation Additional Lineage Documentation	Citation information for a document that describes the lineage of the resource.	For example, additional lineage documentation may include a document that describes in detail the entire process used to generate the resource.	0..*	<<DataType>> CI_Citation (Annex C.5.2)
scope Lineage Scope	The content type restriction and/or spatio-temporal extent limitation within the resource to which lineage information applies.	The lineage scope identifies the portion of the resource to which the lineage information applies or the timeframe for which the lineage information is valid. For example, "lineage information applies only to elevation data collected prior to 20160121."	1	<<DataType>> MD_Scope (Annex C.4.3)
statement Lineage Statement	A general explanation of the knowledge of the resource provider regarding the lineage of the resource.	For example, "this feature was collected by photogrammetric extraction using XYZ imagery taken 20160121."	0..1	<<DataType>> CharacterString
Role: **processStep** Process Step	Information about event(s) and/or transformation(s) in the life of the resource.		0..*	LI_ProcessStep (Annex C.13.2)
Role: **source** Source	Information about resource(s) that were used in creating the resource.		0..*	LI_Source (Annex C.13.3)

C.13.2 LI_ProcessStep

XML Element / Name	Definition	Description	Multiplicity	Type
LI_ProcessStep Resource Process Step (ISO TC211)	Information about an event or transformation in the life of a resource, including the process(es) used to maintain the resource, as determined by ISO 19115-1:2014.	A process step event is an action that occurs at an instance in time that does not change the content of the resource but may change the format of the resource; for example, importing data into a database or application that may reformat the content into an application specific format. A process step transformation is an action that modifies the content of the resource to create new content; for example, applying an algorithm to the resource in order to obtain a set of new values or combining existing content to create new content.		
description Process Step Description	A narrative or other textual description of a process step, including related processing parameters and/or tolerances.	Steps in a process are ordered actions taken with a resource that may preserve or modify its contents. For example, importing data into a database and/or application that may reformat the content into an application specific format or new content may be created by applying an algorithm to the resource and/or combining existing content to create new content.	1	<<DataType>> CharacterString
rationale Process Step Rationale	A narrative or other textual description of the requirement or purpose for a process step.	Steps in a process are ordered actions taken with a resource that may preserve or modify its contents. For example, importing data into a database and/or application that may reformat the content into an application specific format or new content may be created by applying an algorithm to the resource and/or combining existing content to create new content.	0..1	<<DataType>> CharacterString
processor Process Step Processor	A party acting in a role of responsibility for a process step.	Steps in a process are ordered actions taken with a resource that may preserve or modify its contents. For example, importing data into a database and/or application that may reformat the content into an application specific format or new content may be created by applying an algorithm to the resource and/or combining existing content to create new content.	0..*	<<DataType>> CI_Responsibility (Annex C.5.9)
reference Process Step Documentation	Citation information for a document that describes a process step.	Steps in a process are ordered actions taken with a resource that may preserve or modify its contents. For example, importing data into a database and/or application that may reformat the content into an application specific format or new content may be created by applying an algorithm to the resource and/or combining existing content to create new content.	0..*	<<DataType>> CI_Citation (Annex C.5.2)
scope Process Step Scope	The content type restriction and/or spatio-temporal extent limitation of the resource that was affected by a process step.		0..1	<<DataType>> MD_Scope (Annex C.4.3)

XML Element / Name	Definition	Description	Multiplicity	Type
Role:stepDateTime Process Step Date and Time	The date and time, or range of date and time, on or over which a process step occurred.	Steps in a process are ordered actions taken with a resource that may preserve or modify its contents. For example, importing data into a database and/or application that may reformat the content into an application specific format or new content may be created by applying an algorithm to the resource and/or combining existing content to create new content.	0..1	TM_GeometricPrimitive (Annex C.19.1)
Role: **source** Process Step Source	Information about a resource that this process step used to derive another resource.		0..*	LI_Source (Annex C.13.3)

C.13.3 LI_Source

XML Element / Name	Definition	Description	Multiplicity	Type
LI_Source Resource Source (ISO TC211)	Information about a resource that was used to derive another resource, as determined by ISO 19115-1:2014.			
sourceCitation Source Citation	Citation information for a resource that was used to derive another resource.		0..1	<<DataType>> CI_Citation (Annex C.5.2)
description Source Description	A description of the data set that was used to define the digital representation of the feature or data set.	No restriction is placed on the length of the description.	0..1	<<DataType>> CharacterString
sourceMetadata Source Metadata	Citation information for a set of resource metadata for a resource that was used to derive another resource.		0..*	<<DataType>> CI_Citation (Annex C.5.2)
scope Source Scope	The content type restriction and/or spatio-temporal extent limitation of the resource that was used to derive another resource.		0..1	<<DataType>> MD_Scope (Annex C.4.3)
sourceSpatialResolution Resource Spatial Resolution	A numeric factor that provides a general understanding of the density of spatial data in a resource or describes the range of resolutions in which a resource may be used.		0..*	<<Union>> MD_Resolution (Annex C.11.5)
Role: **sourceReferenceSystem** Source Reference System	Information about the spatial or temporal reference system(s) used by representations in the resource that was used to derive another resource.		0..1	MD_ReferenceSystem (Annex C.17.1)

C.14 Lineage Extensions

C.14.1 LE_Algorithm

XML Element / Name	Definition	Description	Multiplicity	Type
LE_Algorithm Algorithm (ISO TC211)	Information about the methodology by which geographic information was derived from instrument readings, as determined by ISO 19115-2:2017.			
citation Algorithm Citation	Citation information for an algorithm used to generate the data.	Citation information for an algorithm may include its version and date.	1	<<DataType>> CI_Citation (Annex C.5.2)
description Algorithm Description	A textual description of the algorithm used to generate the data.		1	<<DataType>> CharacterString

C.14.2 LE_NominalResolution

XML Element / Name	Definition	Description	Multiplicity	Type
LE_NominalResolution Nominal Resolution (ISO TC211)	The distance between consistent parts (for example: centre, left side, or right side) of adjacent pixels, as determined by ISO 19115-2:2017.	A pixel represents the smallest element of a digital image to which attributes are assigned.		<<Union>>
groundResolution Ground Resolution	The distance between consistent parts (for example: centre, left side, or right side) of adjacent pixels in the object space.		1	<<DataType>> Real
scanningResolution Scanning Resolution	The distance between consistent parts (for example: centre, left side, or right side) of adjacent pixels in the scan plane.		1	<<DataType>> Real

C.14.3 LE_Processing

XML Element / Name	Definition	Description	Multiplicity	Type
LE_Processing Processing Information (ISO TC211)	Information about the procedure(s) (for example: software and parameters used), process(es), and algorithm(s) applied in a process step, as determined by ISO 19115-2:2017.	A process step event is an action that occurs at an instance in time that does not change the content of the resource but may change the format of the resource; for example, importing data into a database or application that may reformat the content into an application specific format. A process step transformation is an action that modifies the content of the resource to create new content; for example, applying an algorithm to the resource in order to obtain a set of new values or combining existing content to create new content.		
procedureDescription Procedure Description	A textual description providing additional details about the processing procedures.		0..1	<<DataType>> CharacterString

XML Element / Name	Definition	Description	Multiplicity	Type
documentation Processing Documentation	Citation information for the documentation describing the processing.		0..*	<<DataType>> CI_Citation (Annex C.5.2)
identifier Processing Identifier	A unique identifier to identify the processing package that produced the data.		1	<<DataType>> MD_Identifier (Annex C.4.2)
runTimeParameters Run Time Parameters	The parameters which are entered at run time to control the processing operations.		0..1	<<DataType>> CharacterString
softwareReference Software Reference	Citation information for the document describing the processing software.		0..*	<<DataType>> CI_Citation (Annex C.5.2)
Role: **algorithm** Algorithm	Details of the methodology by which geographic information was derived from instrument readings.		0..*	LE_Algorithm (Annex C.14.1)

C.14.4 LE_ProcessStep

XML Element / Name	Definition	Description	Multiplicity	Type
LE_ProcessStep Procedure Process Step (ISO TC211)	Information about an event or transformation in the life of a resource, including the algorithm(s) and software used for processing the data, as determined by ISO 19115-2:2017.	A process step event is an action that occurs at an instance in time that does not change the content of the resource but may change the format of the resource; for example, importing data into a database or application that may reformat the content into an application specific format. A process step transformation is an action that modifies the content of the resource to create new content; for example, applying an algorithm to the resource in order to obtain a set of new values or combining existing content to create new content.		Subclass of LI_ProcessStep (Annex C.13.2)
Role: **processingInformation** Processing Information	Information about the procedure by which the algorithm was applied to derive geographic data from the raw instrument measurements.	Examples include: datasets, software used, and the processing environment.	0..1	LE_Processing (Annex C.14.3)
Role: **output** Process Step Output	A description of the product generated as a result of the process step.		0..*	LE_Source (Annex C.14.6)
Role: **report** Process Step Report	A report generated by the process step.		0..*	LE_ProcessStepReport (Annex C.14.5)

C.14.5 LE_ProcessStepReport

XML Element / Name	Definition	Description	Multiplicity	Type
LE_ProcessStepReport Process Step Report (ISO TC211)	Information about the report which describes the processing of a resource, as determined by ISO 19115-2:2017.	A process step event is an action that occurs at an instance in time that does not change the content of the resource but may change the format of the resource; for example, importing data into a database or application that may reformat the content into an application specific format. A process step transformation is an action that modifies the content of the resource to create new content; for example, applying an algorithm to the resource in order to obtain a set of new values or combining existing content to create new content.		
description Report Description	A textual description of what occurred during the process step.		0..1	<<DataType>> CharacterString
fileType Report File Type	The type of file that contains the processing report.		0..1	<<DataType>> CharacterString
name Report Name	The name of the processing report.		1	<<DataType>> CharacterString

C.14.6 LE_Source

XML Element / Name	Definition	Description	Multiplicity	Type
LE_Source Process Step Output (ISO TC211)	Information about a resource's input to or output by the processing step, as determined by ISO 19115-2:2017.	A process step event is an action that occurs at an instance in time that does not change the content of the resource but may change the format of the resource; for example, importing data into a database or application that may reformat the content into an application specific format. A process step transformation is an action that modifies the content of the resource to create new content; for example, applying an algorithm to the resource in order to obtain a set of new values or combining existing content to create new content.		Subclass of LI_Source (Annex C.13.3)
processedLevel Processed Level	The processing level of the source data.		0..1	<<DataType>> MD_Identifier (Annex C.4.2)
resolution Source Resolution	The distance between consistent parts (for example: centre, left side, or right side) of two adjacent pixels.		0..1	<<Union>> LE_NominalResolution (Annex C.14.2)

C.15 Maintenance Information

C.15.1 MD_MaintenanceInformation

XML Element / Name	Definition	Description	Multiplicity	Type
MD_MaintenanceInformation Resource Maintenance Information (ISO TC211)	Information about the scope and update frequency of the resource, as determined by ISO 19115-1:2014.			
maintenanceAndUpdateFrequency Resource Maintenance and Update Frequency	The rate at which changes and/or additions are made to the resource after the initial creation is completed.	Resource maintenance frequency is the frequency with which changes and/or additions are made to the resource after the initial creation is completed. Examples include: annually, hourly, periodic, and irregular (non-exhaustive).	1	<<CodeList>> MD_MaintenanceFrequencyCode (Annex D.7.1)
maintenanceDate Resource Maintenance Date	A date on which a resource was, or will be, maintained.	Maintenance includes initial content creation, revisions to existing content, additions to existing content, and verification of existing content.	0..*	<<DataType>> CI_Date (Annex C.5.4)
maintenanceNote Resource Maintenance Note	A specific requirement for maintaining a resource.	For example, specific requirements for maintaining the resource may include updating the resource on the third Tuesday of the month.	0..*	<<DataType>> CharacterString
contact Resource Maintenance Contact	A party acting in a role of responsibility for maintaining a resource.	Maintenance includes initial content creation, revisions to existing content, additions to existing content, and verification of existing content.	0..*	<<DataType>> CI_Responsibility (Annex C.5.9)

C.16 Metadata Information

C.16.1 MD_Metadata

XML Element / Name	Definition	Description	Multiplicity	Type
MD_Metadata Resource Metadata (ISO TC211)	Information that is about a resource, as determined by ISO 19115-1:2014.	Resource metadata is information about the identification, application schema, portrayal catalogue, content, reference system, maintenance, scope, legal constraints, security constraints, quality, spatial and/or temporal schema, spatial reference, and/or distributor(s) of the resource.		
dateInfo Resource Metadata Date	The date, and optionally time, of an event involving a set of resource metadata.	Examples of events include: creation, release, distribution, and revision.	1..*	<<DataType>> CI_Date (Annex C.5.4)

XML Element / Name	Definition	Description	Multiplicity	Type
defaultLocale Text Locale	The cultural and linguistic setting applicable to the interpretation of a character string.	Specified by a combination of language, potentially a country, and a character encoding (character set).	1	<<DataType>> PT_Locale (Annex C.12.1)
contact Resource Metadata Contact	The party acting in a role of responsibility for a set of resource metadata.	Resource metadata is information about the identification, application schema, portrayal catalogue, content, reference system, maintenance, scope, legal constraints, security constraints, quality, spatial and/or temporal schema, spatial reference, and/or distributor(s) of the resource.	1..*	<<DataType>> CI_Responsibility (Annex C.5.9)
metadataIdentifier Resource Metadata Identifier	A unique identifier for a set of resource metadata.		1	<<DataType>> MD_Identifier (Annex C.4.2)
metadataStandard Metadata Standard Reference	A standardized reference for a standard (or specification) which determines the structure and content of a set of metadata.	This is the means by which the version of a metadata standard (Information Security Markings or NSG Metadata Foundation for example) used by the metadata would be indicated.	1	<<DataType>> CI_Citation (Annex C.5.2)
parentMetadata Parent Metadata Reference	A standardized reference to a set of metadata that is in a parent relationship to this set of resource metadata.	If a metadata record owns or contains other metadata records (example: metadata about a resource series), it is said to be in a parent relationship.	0..1	<<DataType>> CI_Citation (Annex C.5.2)
Role: dataQualityInfo Data Quality Information	Information about the assessed quality of the resource.		1	DQ_DataQuality (Annex C.21.1)
Role: distributionInfo Distribution Information	Information about the mechanism(s) available for obtaining the resource.	For example, the distributor of and options for obtaining the resource.	1	MD_Distribution (Annex C.8.2)
Role: identificationInfo Resource Identification Information	Basic information required to uniquely identify the resource.		1..*	MD_Identification (Annex C.11.2)
Role: metadataConstraints Metadata Constraints	Information about the security and legal restrictions on the access to and/or use of this resource metadata.		1..*	MD_Constraints (Annex C.6.1)
Role: metadataScope Resource Metadata Scope	Information about the type of resource for which metadata is provided, and a description of that resource type.	Information about the type of resource for which metadata is provided, and a description of that resource type.	1	MD_MetadataScope (Annex C.16.2)

XML Element / Name	Definition	Description	Multiplicity	Type
Role: referenceSystemInfo Reference System Information	Information about the spatial or temporal reference system(s) used in the resource.		1	MD_ReferenceSystem (Annex C.17.1)
Role: resourceLineage Resource Lineage	Information about the provenance, source(s), and/or the production process(es) applied to the resource.		1	LI_Lineage (Annex C.13.1)
Role: spatialRepresentationInfo Spatial Representation Information	Information about the digital mechanism(s) used to represent the spatial information in the resource.		1	MD_SpatialRepresentation (Annex C.18.3)

C.16.2 MD_MetadataScope

XML Element / Name	Definition	Description	Multiplicity	Type
MD_MetadataScope Metadata Scope (ISO TC211)	Applicability of the resource metadata to a specified resource type, as determined by ISO 19115-1:2014.	Resource type, or scope, may be determined from a variety of perspectives; for example, based on its subject matter (for example: a specific feature or property type), its structure (for example: consisting of a data series or an aggregate of other resources), or its purpose (for example: related to an initiative or a field session, or serving as a repository).		
resourceScope Resource Scope	A brief indicator of the type of resource for which metadata information is reported.	For example, a resource scope may be information that is reported only for feature types.	1	<<CodeList>> MD_ScopeCode (Annex D.2.1)
resourceScopeName Resource Scope Name	A word or phrase that describes the type of resource for which information is reported.	Resource scope name can be more descriptive or specific about the particular type of resource being described than the resource scope code indicates. For example, in the case where information is reported only for feature types whose instances participate in transportation networks, the resource scope name may be “Transportation Networks”.	1	<<DataType>> CharacterString

C.17 Reference System Information

C.17.1 MD_ReferenceSystem

XML Element / Name	Definition	Description	Multiplicity	Type
MD_ReferenceSystem Reference System Specification (ISO TC211)	Information about a spatial or temporal reference system used by representations in the resource, as determined by ISO 19115-1:2014.			

XML Element / Name	Definition	Description	Multiplicity	Type
referenceSystemIdentifier Reference System Identifier	An unambiguous identifier of a spatial and/or temporal reference system.	Refer to International Organization of Standardization (ISO) 19111 and ISO 19111-2 when coordinate reference system information is not given through reference system identifier (for example: “EPSG::4326”).	1	<<DataType>> MD_Identifier (Annex C.4.2)
referenceSystemType Reference System Type	The type of a spatio-temporal reference system.	For example, a compound geographic 2-dimensional parametric type of spatio-temporal reference system.	0..1	<<CodeList>> MD_ReferenceSystemTypeCode (Annex D.8.1)

C.18 Spatial Representation Information

C.18.1 MD_Dimension

XML Element / Name	Definition	Description	Multiplicity	Type
MD_Dimension Axis Dimension Specification (ISO TC211)	The properties specifying the name, size, resolution, title, and description of a spatio-temporal Axis that is used to define a gridded spatial representation, as determined by ISO 19115-1:2014.	A gridded spatial representation identifies position in the real world as determined by a network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in an algorithmic way. The intersection of the curves partition the space into a multidimensional grid of cells.		<<DataType>>
dimensionName Axis Dimension Name	The name of a spatio-temporal axis that is used to define a gridded spatial representation.	A gridded spatial representation identifies position in the real world as determined by a network composed of two or more sets of curves (axes) in which the members of each set intersect the members of the other sets in an algorithmic way. The intersection of the curves partition the space into a multidimensional grid of cells and the curves provide a fixed reference line for the measurement of coordinates. A spatio-temporal axis has a name; for example: row, column, vertical, track, cross track, line, sample, or time.	1	<<CodeList>> MD_DimensionNameTypeCode (Annex D.9.2)
dimensionSize Axis Dimension Size	The number of elements along a spatio-temporal axis used to define a gridded spatial representation.	A gridded spatial representation identifies position in the real world as determined by a network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in an algorithmic way. The intersection of the curves partition the space into a multidimensional grid of cells.	1	<<DataType>> Integer

XML Element / Name	Definition	Description	Multiplicity	Type
resolution Axis Dimension Resolution	The element resolution along a spatio-temporal axis that is used to define a gridded spatial representation.	A gridded spatial representation identifies position in the real world as determined by a network composed of two or more sets of curves (axis) in which the members of each set intersect the members of the other sets in an algorithmic way. The intersection of the curves partition the space into a multidimensional grid of cells and the curves provide a fixed reference line for the measurement of coordinates. Element resolution is the degree of detail in the grid dataset.	0..1	<<DataType>> Measure (Annex C.3)

C.18.2 MD_GridSpatialRepresentation

XML Element / Name	Definition	Description	Multiplicity	Type
MD_GridSpatialRepresentation Gridded Spatial Representation Characteristics (ISO TC211)	Information about a gridded spatial representation used by the resource, as determined by ISO 19115-1:2014.	A gridded spatial representation identifies position in the real world as determined by a network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in an algorithmic way. The intersection of the curves partition the space into a multidimensional grid of cells.		Subclass of {abstract} MD_SpatialRepresentation (Annex C.18.3)
cellGeometry Grid Cell Geometry	Identification of a gridded spatial representation which consists of cells that represent points or areas.	A gridded spatial representation identifies position in the real world as determined by a network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in an algorithmic way. The intersection of the curves partition the space into a multidimensional grid of cells. Cells representing points are zero-dimensional geometric primitives that represent a position. Cells representing areas are two-dimensional geometric primitives that represent a position.	1	<<CodeList>> MD_CellGeometryCode Value = 'point' (Annex D.9.1)
axisDimensionProperties Grid Axis Dimension Properties	A spatio-temporal axis that is used to define a gridded spatial representation.	A gridded spatial representation identifies position in the real world as determined by a network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in an algorithmic way. The intersection of the curves partition the space into a multidimensional grid of cells.	2 {ordered}	<<DataType>> MD_Dimension (Annex C.18.1)
transformationParameterAvailability Grid Coordinate Transformation Parameters Available	An indication that parameters for a transformation between image coordinates and geographic or map coordinates exist (are available).	A gridded spatial representation identifies position in the real world as determined by a network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in an algorithmic way. The intersection of the curves partition the space into a multidimensional grid of cells. Transformation parameters provide conversion factors for use in calculating the same position within two reference systems. When this attribute is encoded numerically, 0 = no and 1 = yes.	1	Boolean Value = 'true'

XML Element / Name	Definition	Description	Multiplicity	Type
numberOfDimensions Number of Grid Dimensions	The number of independent spatio-temporal axes of a gridded spatial representation.	A gridded spatial representation identifies position in the real world as determined by a network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in an algorithmic way. The intersection of the curves partition the space into a multidimensional grid of cells.	1	<<DataType>> Integer Value = '2'

C.18.3 MD_SpatialRepresentation

XML Element / Name	Definition	Description	Multiplicity	Type
MD_SpatialRepresentation Resource Spatial Representation (ISO TC211)	Information about a spatial representation used by a resource, as determined by ISO 19115-1:2014.	A spatial representation is a description of a position in the real world. A resource is an identifiable asset or means that fulfils a requirement.		{abstract}

C.19 Temporal Information

C.19.1 TM_GeometricPrimitive

XML Element / Name	Definition	Description	Multiplicity	Type
TM_GeometricPrimitive Temporal Geometric Primitive (ISO TC211)	Abstract class that provides information about a temporal position, as determined by ISO 19108:2002/Cor.1:2006. In NEMIS, temporal information is encoded using the Geography Markup Language (GML) classes described in Annex C.10.			{abstract}

C.20 Imagery Acquisition Information

C.20.1 MI_AcquisitionInformation

XML Element / Name	Definition	Description	Multiplicity	Type
MI_AcquisitionInformation Acquisition Information (ISO TC211)	Information about the acquisition of geospatial data using imagery, sensors, and other acquisition methods, as determined by ISO 19115-2:2017.	For example: the designations for the measuring instruments used, the platform carrying the measuring instruments, and the mission to which the data contributes.		
scope Acquisition Scope	The content type restriction and/or spatio-temporal extent limitation of the specific data to which the acquisition information applies.		0..1	<<DataType>> MD_Scope (Annex C.4.3)

XML Element / Name	Definition	Description	Multiplicity	Type
instrument Acquisition Instrument	Information about the measuring instrument used in the data acquisition.		0..*	MI_Instrument (Annex C.20.3)
platform Platform	Information about the platform from which the data were taken.		0..*	MI_Platform (Annex C.20.5)
Role: environmentalConditions Environmental Conditions	A record of the environmental circumstances during the data acquisition.	For example, the average air temperature.	0..1	MI_EnvironmentalRecord (Annex C.20.2)

C.20.2 MI_EnvironmentalRecord

XML Element / Name	Definition	Description	Multiplicity	Type
MI_EnvironmentalRecord Environmental Record (ISO TC211)	Information about the environmental conditions during the acquisition, as determined by ISO 19115-2:2017.	For example: the average air temperature.		
maxAltitude Acquisition Maximum Altitude	The highest altitude during the image collection.		0..1	<<DataType>> Real
averageAirTemperature Average Air Temperature	The average air temperature along the flight pass during the image collection.	A pass is a single instance of a remote, mobile measuring system going by a target of interest.	0..1	<<DataType>> Real
maxRelativeHumidity Maximum Relative Humidity	The highest relative humidity along the flight pass during the image collection.	Relative humidity is a ratio of the amount of water vapour present in air at a specific temperature to the maximum amount of water vapour that air could hold at the same temperature.	0..1	<<DataType>> Real
meteorologicalConditions Meteorological Conditions	The meteorological conditions in the image collection area.	For example: clouds, snow, and wind.	0..1	<<DataType>> CharacterString
solarAzimuth Solar Azimuth Angle	The clockwise angle, measured in degrees from north to the centre of the sun's disc.	This angle is calculated from the nadir point of the sensor, not at the centre point of the image.	0..1	<<DataType>> Real
solarElevation Solar Elevation Angle	The angle between the horizon and the centre of the sun's disc.		0..1	<<DataType>> Real

C.20.3 MI_Instrument

XML Element / Name	Definition	Description	Multiplicity	Type
MI_Instrument Measuring Instrument (ISO TC211)	Information describing characteristics of the measuring instrument used to acquire the data, as determined by ISO 19115-2:2017.	For example: a sensor.		

XML Element / Name	Definition	Description	Multiplicity	Type
identifier Measuring Instrument Identifier	A unique identifier of the measuring instrument used to acquire data.		1	<<DataType>> MD_Identifier (Annex C.4.2)
citation Measuring Instrument Citation	Citation information for a measuring instrument used to acquire data.		0..*	<<DataType>> CI_Citation (Annex C.5.2)
description Measuring Instrument Description	A textual description of the measuring instrument.		0..1	<<DataType>> CharacterString
type Measuring Instrument Type	The name of the type of measuring instrument used to acquire data.	For example: framing, line-scan, push-broom, and pan-frame.	1	<<DataType>> CharacterString
Role: **mountedOn** Mounted On	The platform on which the instrument is mounted.		0..1	MI_Platform (Annex C.20.5)

C.20.4 MI_Metadata

XML Element / Name	Definition	Description	Multiplicity	Type
MI_Metadata Imagery and Gridded Data Metadata (ISO TC211)	Information about imagery or gridded data, as determined by ISO 19115-2:2017.	Imagery is a representation of phenomena as images produced by electronic and/or optical techniques. Gridded data is data whose attribute values are associated with positions on a grid coordinate system.		Subclass of MD_Metadata (Annex C.16.1)
Role: **acquisitionInformation** Acquisition Information	Information about the acquisition of the data.		1	MI_AcquisitionInformation (Annex C.20.1)

C.20.5 MI_Platform

XML Element / Name	Definition	Description	Multiplicity	Type
MI_Platform Acquisition Platform (ISO TC211)	The designation of the platform used to acquire the dataset, as determined by ISO 19115-2:2017.	A platform is a structure which supports a sensor or sensors.		
identifier Acquisition Platform Identifier	The unique identification of the acquisition platform.	An acquisition platform is a structure which supports a sensor or sensors.	1	<<DataType>> MD_Identifier (Annex C.4.2)
citation Acquisition Platform Citation	Citation information for the source where information about the platform is described.	An acquisition platform is a structure which supports a sensor or sensors.	0..1	<<DataType>> CI_Citation (Annex C.5.2)

XML Element / Name	Definition	Description	Multiplicity	Type
description Acquisition Platform Description	A textual description of the platform supporting the instrument.	An acquisition platform is a structure which supports a sensor or sensors.	1	<<DataType>> CharacterString
sponsor Acquisition Platform Sponsor	The organisation responsible for building, launching, or operating the platform.	An acquisition platform is a structure which supports a sensor or sensors.	0..*	<<DataType>> CI_Responsibility (Annex C.5.9)

C.21 Data Quality

C.21.1 DQ_DataQuality

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_DataQuality Data Quality (ISO TC211)	An assessment of the quality of a resource, as determined by ISO 19157:2013.	The assessment applies to a specified portion of the resource, and may be based on results from more than one quality measure.		
scope Data Quality Scope	The content type restriction and/or spatio-temporal extent limitation of a resource to which quality information applies.		1	<<DataType>> MD_Scope (Annex C.4.3)
Role: **report** Quality Report	Specific assessment(s) of the quality of the resource.	Specific assessments of the quality of the resource may include the specification of a quality measure, the conditions under which the quality measure was applied, and the value of the measure result.	1..*	DQ_Element (Annex C.21.2)
Role: **standaloneQualityReport** Standalone Quality Report	Information about a separate, self-contained report on the quality of the resource.	Fully detailed information, including specific measure(s), evaluation procedure(s), aggregated results, and aggregation method(s) is specified in a standalone quality report for a complete quality analysis of the resource.	0..1	DQ_StandaloneQualityReportInformation (Annex C.21.11)

C.21.2 DQ_Element

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_Element Quality Element (ISO TC211)	An assessment of the quality of the resource, consisting of the specification of a quality measure, the conditions under which the quality measure was applied, and the value(s) of the measure result, as determined by ISO 19157:2013.			{abstract}

XML Element / Name	Definition	Description	Multiplicity	Type
standaloneQualityReportDetails Standalone Quality Report Details	The portion of a standalone quality report where a quality element(s), or any related quality elements, is described.	A standalone quality report includes specific measure(s), evaluation procedure(s), aggregated results, and aggregation method(s). A quality element is a specific assessment of the quality of the resource, consisting of the specification of a quality measure, the conditions under which the quality measure was applied, and the value of the measure result. Related quality elements are quality elements that document original results in the case of a quality result being derived from another quality report or being included in an aggregation of multiple quality reports.	0..1	<<DataType>> CharacterString
Role: **result** Quality Element Result	The value (or set of values) resulting from the application of a quality measure to a resource.	In some cases the quality element result may be the outcome of evaluating an original quality element result value (or set of values) against a specified acceptable conformance quality level as part of a pass or fail determination.	1..*	DQ_Result (Annex C.22.1)
Role: **measure** Quality Element Measure	Information specifying the components (for example: name, basic measure, definition, parameter, or value type) of a quality measure for evaluating and reporting data quality.	A quality measure is a quantitative value described using a numeric amount with a scale or using a scalar reference system to specify the characteristics and attributes of a product.	0..1	DQ_MeasureReference (Annex C.21.10)

C.21.3 DQ_PositionalAccuracy

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_PositionalAccuracy Data Positional Accuracy (ISO TC211)	An assessment of the quality of a resource based on the accuracy of the position of its spatial content (for example: features), as determined by ISO 19157:2013.	The position is referenced by coordinate values. Accuracy is the closeness of agreement between a test result or measurement result and the true value. Positional accuracy is the accuracy of the position of features within a spatial reference system.		{abstract} Subclass of {abstract} DQ_Element (Annex C.21.2)

C.21.4 DQ_AbsoluteExternalPositionalAccuracy

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_AbsoluteExternalPositionalAccuracy Data Absolute External Positional Accuracy (ISO TC211)	An assessment of the quality of a resource based on the proximity of the reported positions of its spatial content (for example: features) to values accepted as, or known to be, true, as determined by ISO 19157:2013.	The position is referenced by coordinate values. Examples of measures of external positional accuracy include the mean value of positional uncertainties or the number of positional uncertainties above a given threshold for a set of positions.		Subclass of {abstract} DQ_PositionalAccuracy (Annex C.21.3)

C.21.5 DQ_RelativeInternalPositionalAccuracy

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_RelativeInternalPositionalAccuracy Data Relative Internal Positional Accuracy (ISO TC211)	An assessment of the quality of a resource based on the proximity of the reported relative positions of its spatial content (for example: features) to their respective relative positions accepted as, or known to be, true, as determined by ISO 19157:2013.	The position is referenced by coordinate values. Examples of measures of internal positional accuracy include the relative vertical error or the relative horizontal error.		Subclass of {abstract} DQ_PositionalAccuracy (Annex C.21.3)

C.21.6 DQ_Completeness

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_Completeness Data Completeness (ISO TC211)	An assessment of the quality of a resource based on a stated content specification and the presence and absence of instances of required features, their attributes, and/or their relationships, as determined by ISO 19157:2013.	A content specification is a data product specification or user requirement against which data is being evaluated.		{abstract} Subclass of {abstract} DQ_Element (Annex C.21.2)

C.21.7 DQ_CompletenessCommission

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_CompletenessCommission Data Completeness Commission (ISO TC211)	An assessment of the quality of a resource based on a stated content specification and the presence of excess data, as determined by ISO 19157:2013.	A content specification is a data product specification or user requirement against which data is being evaluated. The presence of excess data in a dataset is based on the scope of the dataset; for example, the number of excess items or the number of duplicate feature instances in a dataset.		Subclass of {abstract} DQ_Completeness (Annex C.21.6)

C.21.8 DQ_LogicalConsistency

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_LogicalConsistency Data Logical Consistency (ISO TC211)	An assessment of the quality of a resource based on a stated logical schema, and the degree of its inheritance to the stated rules, as determined by ISO 19157:2013.	A logical schema is the logical rules of data structure, attribution, and relationships. The degree of adherence to a logical schema provides an indication that an item complies with the rules of the relevant conceptual schema. The data structure can be conceptual, logical, or physical.		{abstract} Subclass of {abstract} DQ_Element (Annex C.21.2)

C.21.9 DQ_TopologicalConsistency

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_TopologicalConsistency Data Logical Consistency (ISO TC211)	An assessment of the quality of a resource based on a stated content specification and the degree of adherence of its explicitly encoded topological characteristics to the stated requirements, as determined by ISO 19157:2013.	A content specification is a data product specification or user requirement against which data is being evaluated. Examples of the degree of adherence of explicitly encoded topological characteristics include the number of faulty point-curve connections where different curves touch in the dataset or the count of all items in the dataset that are invalid sliver surfaces where the borders of the adjacent surfaces may unintentionally gap or overlap by small amounts to cause a topological error.		Subclass of {abstract} DQ_LogicalConsistency (Annex C.21.8)

C.21.10 DQ_MeasureReference

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_MeasureReference Quality Measure Reference (ISO TC211)	A reference to the specification of a quality measure, as determined by ISO 19157:2013.	A reference is an additional source of authoritative information. The reference is usually to a quality measure that has been specified in a measure reference or catalogue.		{abstract}
measureIdentification Quality Measure Identification	A unique identifier of a quality measure applied to the data in a quality assessment.	A quality measure determines the degree to which a set of inherent characteristics of a resource fulfil a stated requirement.	0..1	<<DataType>> MD_Identifier (Annex C.4.2)
nameofMeasure Quality Measure Name	The name of a quality measure.	A quality measure determines the degree to which a set of inherent characteristics of a resource fulfil a stated requirement.	0..1	<<DataType>> CharacterString
measureDescription Quality Measure Summary Description	A summary textual description of a quality measure applied to the data in a quality assessment.	A quality measure determines the degree to which a set of inherent characteristics of a resource fulfil a stated requirement.	0..1	<<DataType>> CharacterString

C.21.11 DQ_StandaloneQualityReportInformation

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_StandaloneQualityReportInformation Standalone Quality Report Information (ISO TC211)	Information identifying a separate, self-contained report on the quality of the resource, as determined by ISO 19157:2013.	Fully detailed information, including specific measure(s), evaluation procedure(s), aggregated results, and aggregation method(s) is specified in a standalone quality report for a complete quality analysis of the resource.		
reportReference Quality Report Reference	Citation information for a self-contained report on the quality of a resource.	Fully detailed information, including specific measures, evaluation procedures, aggregated results, and aggregation methods, is specified in a standalone quality report for a complete quality analysis of the resource. Citation information for a standalone quality report includes identifying information such as title and date.	1	<<DataType>> CI_Citation (Annex C.5.2)

XML Element / Name	Definition	Description	Multiplicity	Type
abstract Quality Report Abstract	A summary of a separate, self-contained quality report on the quality of a resource.	Fully detailed information, including specific measures, evaluation procedures, aggregated results, and aggregation methods, is specified in a standalone quality report for a complete quality analysis of the resource.	1	<<DataType>> CharacterString

C.22 Data Quality – Result

C.22.1 DQ_Result

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_Result Data Quality Result (ISO TC211)	The value resulting from the application of a quality measure to a resource, as determined by ISO 19157:2013.	The data quality result value may only apply to a specified portion of the resource.		{abstract}
dateTime Quality Result Time	The date and, optionally, time when a quality measure result was determined.	Midnight is understood to be 00:00:00 (the beginning of a day); when the time is not specified then midnight in the local time zone is typically implied.	0..1	<<DataType>> DateTime
resultScope Quality Result Scope	The scope of the resource to which the value resulting from the application of a quality measure to the resource applies.	A scope is the extent, spatial and/or temporal, and/or common characteristic(s) that identify the data on which data quality is to be evaluated.	0..1	<<DataType>> MD_Scope (Annex C.4.3)

C.22.2 DQ_ConformanceResult

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_ConformanceResult Data Quality Conformance Result (ISO TC211)	The value resulting from the application of a quality measure to a resource when the outcome of evaluating that quality measure is compared to a specified acceptable conformance quality level, as determined by ISO 19157:2013.	The conformance quality level may be specified in suitable reference documentation such as the data product specification or a user-defined requirements specification.		Subclass of {abstract} DQ_Result (Annex C.22.1)
explanation Quality Conformance Explanation	A statement clarifying the meaning of quality conformance for a quality conformance result.	Quality conformance is a measure of the degree to which a set of inherent characteristics fulfils requirements.	0..1	<<DataType>> CharacterString
pass Quality Conformance Pass	An indication of the result of applying a quality conformance test.	When encoded numerically, 0 = “fails to conform” and 1 = “pass (conforms)”.	1	Boolean
specification Quality Conformance Specification	Citation information for a data product specification or user requirement against which a resource is being evaluated.		1	<<DataType>> CI_Citation (Annex C.5.2)

C.22.3 DQ_DescriptiveResult

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_DescriptiveResult Data Quality Descriptive Result (ISO TC211)	The value resulting from the application of a quality measure to a resource when the outcome of evaluating that quality measure is a qualitative value that is reported descriptively, as determined by ISO 19157:2013.	For example, a subjective evaluation of the resource is expressed with a textual statement indicating that the relative positional accuracy is higher between a given geological feature and a nearby feature from a base map than is the absolute positional accuracy on the geological feature itself. The descriptive result can also be used to provide a short synthetic description of the result of the quality evaluation, to accompany the complete quantitative result or to replace it, if no quantitative value can be provided.		Subclass of {abstract} DQ_Result (Annex C.22.1)
statement Quality Descriptive Result Statement	A textual expression of the result from a descriptive quality measure.		1	<<DataType>> CharacterString

C.22.4 DQ_QuantitativeResult

XML Element / Name	Definition	Description	Multiplicity	Type
DQ_QuantitativeResult Data Quality Quantitative Result (ISO TC211)	The value resulting from the application of a quality measure to a resource when the outcome of evaluating that quality measure is a quantitative value (for example: numeric), as determined by ISO 19157:2013.	The quantitative value is usually accompanied by the specification of a physical quantity and applicable unit of measure.		Subclass of {abstract} DQ_Result (Annex C.22.1)
value Quality Measure Quantitative Value	A quantitative value for a quality measure that was determined in accordance with a specified evaluation procedure.	In accordance with ISO 19103, the Quality Quantitative Value is a heterogeneous aggregation of values of component data types, each aggregation having one value for each component data type, keyed by a fixed field-identifier [ISO/IEC 11404]. The structure of the aggregation is determined by the Quality Quantitative Value Type.	1	<<DataType>> Record

C.23 SWE Common

C.23.1 Record

XML Element / Name	Definition	Description	Multiplicity	Type
Record Record (ISO TC211)	A heterogeneous aggregation of data elements in which the individual elements are identified by names, as determined by ISO 19103:2015.	A record is a collection of elements, possibly of different data types, typically in fixed number and sequence.		{abstract} <<DataType>>

C.23.2 AbstractSWEIdentifiable

XML Element / Name	Definition	Description	Multiplicity	Type
AbstractSWEIdentifiable Sensor Web Identifiable (OGC SWE)	An abstract modelling class that is a superclass for all Sensor Web Enablement (SWE) Common objects with identification metadata, as determined by the OGC SWE Common Data Model Encoding Standard.			{abstract} <<DataType>> Subclass of {abstract} Record
label	Textual label for the data component. This is often used for displaying a human readable name for a dataset field or a process input/output.		0..1	

C.23.3 AbstractDataComponent

XML Element / Name	Definition	Description	Multiplicity	Type
AbstractDataComponent Sensor Web Data Component (OGC SWE)	An abstract modelling class that is a superclass for all Sensor Web Enablement (SWE) Common data components, which are elements of sensor data definitions corresponding to an atomic or aggregate datatype, as determined by the OGC SWE Common Data Model Encoding Standard.	A dataset is composed of data components whose values need to be put into context in order to be fully understood and interpreted, by either humans or machines. Data components are used to describe all types of data structures, whether they represent data stream contents, tasking messages, or process inputs/outputs. For example: a data record is a data component of a dataset.		{abstract} <<DataType>> Subclass of {abstract} AbstractSWEIdentifiable (Annex C.23.2)
@definition Sensor Web Data Component Definition	A reference (using a scoped name) to semantic information defining the precise nature of a sensor web data component.	The reference should map to a controlled term defined in a web-accessible dictionary, registry, or ontology. The term will have a textual definition agreed upon by one or more communities and may also include pictures, diagrams, and other semantic information. For example, the definition may indicate that the value represents an atmospheric temperature using a URN such as “urn:ogc:def:property:OGC::SamplingTime” referencing the complete definition in a register, or the definition may be a URL linking to a concept defined in an ontology such as “http//www.opengis.net/def/OGC/0/SamplingTime”.	0..1	<<DataType>> URI

C.23.4 AbstractSimpleComponent

XML Element / Name	Definition	Description	Multiplicity	Type
AbstractSimpleComponent Sensor Web Simple Data Component (OGC SWE)	An abstract modelling class that is a superclass for all Sensor Web Enablement (SWE) Common simple data components, which are elements of sensor data definitions corresponding to a scalar or range, as determined by the OGC SWE Common Data Model Encoding Standard.	A simple data component is designed to collect information about the nature, representation, and quality of data. A scalar representation only has a magnitude; it is without direction. Examples of scalar data components include Boolean, Text, Category, Count, Quantity, and Time. A range representation is used for specifying the extents of property values. Examples of range data components include CategoryRange, CountRange, QuantityRange, and TimeRange.		{abstract} <<DataType>> Subclass of {abstract} AbstractDataComponent (Annex C.23.3)

C.23.5 Quantity

XML Element / Name	Definition	Description	Multiplicity	Type
Quantity Sensor Web Quantity (OGC SWE)	A scalar data component with decimal representation accompanied by a unit of measure that are used together to store the value of a continuous quantity, as determined by the OGC Sensor Web Enablement (SWE) Common Data Model Encoding Standard.	Quantity is often used in the science and technical communities, as the majority of properties measured by sensors can be represented by numbers. For example: temperature measurements can be represented by a number associated to a unit of measure such as “degrees Celsius”, and a velocity vector is composed of several values associated to a unit of measure of “speed”.		<<DataType>> Subclass of {abstract} AbstractSimpleComponent (Annex C.23.4)
uom Sensor Web Quantity Unit of Measure	The unit of measure used to express a value of a sensor web quantity data component.	The unit of measure is essential for the correct interpretation of data represented as decimal numbers. Quantities with no physical unit still have a scale (for example: unity, percent, or per thousands).	1	<<DataType>> URI
value Sensor Web Quantity Value	A sensor web data component real value that is expressed in accordance with an accompanying unit of measure.	For example: the quantity value of 23.51, which is expressed in degrees Celsius.	1	<<DataType>> Real

C.24 NAS – Entity Metadata

C.24.1 DataProcessStep

XML Element / Name	Definition	Description	Multiplicity	Type
DataProcessStep Data Process Step	Information about an event or transformation in the life of a data resource, including the process(es) used to maintain the data resource.	A data resource consists of the specification of a data entity and/or its properties. Data resource maintenance includes, for example, creation, review, and update. A process step transformation is an action that modifies the content of the data resource to create new content; for example, applying an algorithm to the data resource in order to obtain a set of new values or combining existing content to create new content.		Subclass of LE_ProcessStep (Annex C.14.4)
creationProcComplete Creation Process Complete	An indication that the process by which the digital representation of the feature(s) or data set(s) within an area is created, is complete in accordance with the specification that was used as the basis for defining the digital representation of the feature(s) or data set(s).		0..1	Boolean

XML Element / Name	Definition	Description	Multiplicity	Type
featureExtractSoftware Feature Extraction Software	The software used to derive features from an image source.	Electronic Light Table (ELT) software may implement different algorithms and sensor models which may introduce varying types and degrees of feature positioning errors.	0..1	<<CodeList>> FeatureExtractSoftwareCodeList (Annex D.11.1)
imageRectificationMethod Image Rectification Method	The type of rectification process that was used to conform an image to align it with a standard coordinate system (for example: a map projection).		0..1	<<CodeList>> ImageRectificationMethodCodeList (Annex D.11.2)
processStepType Process Step Type	A type of event or transformation in the life of a data resource, including the process(es) used to maintain the resource.		0..1	<<CodeList>> ProcessStepType (Annex D.11.3)
uniqueEntityIdentifier Unique Entity Identifier	The globally unique and persistent identifier of an entity (for example: feature or event) instance as specified by a Uniform Resource Name (URN) in accordance with the Internet Engineering Task Force (IETF) RFC2396 and RFC2141.	It is based on the Uniform Resource Identifier (URI), a compact string of characters for identifying an abstract or physical resource. The term 'Uniform Resource Name' (URN) refers to the subset of URI that are required to remain globally unique and persistent even when the resource ceases to exist or becomes unavailable. The URN is drawn from one of a set of defined namespaces, each of which has its own set name structure and assignment procedures.	1	<<DataType>> UniqueResourceIdentStrucText (Annex D.11.4)
Role: priorProcessStep Prior Process Step	The process step(s) occurring immediately before this process step.	The output of the prior process step may be input to this process step.	0..*	DataProcessStep (Annex C.24.1)
Role: nextProcessStep Next Process Step	The process step(s) occurring immediately after this process step.	The output of this process step may be input to the next process step.	0..*	DataProcessStep (Annex C.24.1)

C.25 NAS – Resource Metadata

C.25.1 DataIdentification

XML Element / Name	Definition	Description	Multiplicity	Type
DataIdentification Data Identification	Information, not defined in the base standard, that uniquely identifies a data resource.			Subclass of MD_DataIdentification (Annex C.11.1)

XML Element / Name	Definition	Description	Multiplicity	Type
resourceCategory Resource Category	The particular category of a data resource within a defined taxonomy.	Resources within a category have similar information content and have been produced by similar processing methods.	1	<<CodeList>> ResourceCategory (Annex D.14.1)
revisionRecall Revision Recall	Information about action(s) to be taken regarding modifications to the data resource (revision) or withdrawal of the data resource (recall).	Revision or recall information allows recipients to be aware of modifications and withdrawal and to take mandatory actions in regards to previous versions (for example: immediately destroy all copies of the product).	0..1	<<DataType>> RevisionRecall
Role: electronicRecordsManagement Electronic Records Management	Information used by a records management system to manage this resource.	A records management system systematically controls the creation, distribution, use, maintenance, and disposition of recorded information maintained as evidence of business activities and transactions.	0..1	ElectronicRecordsManagement

C.25.2 IANACharset

XML Element / Name	Definition	Description	Multiplicity	Type
IANACharset IANA Charset Codelist	A codelist, each domain member of which denotes an IANA charset.	The set of charsets recognized through the Internet Assigned Numbers Authority (IANA) registration procedure established by RFC 2978 (IANA Charset Registration Procedures); a charset (referred to as a “character set” in the past) is a method of converting a sequence of octets into a sequence of characters, optionally producing additional control information such as directionality indicators.		<<CodeList>> Subclass of {abstract} Codelist

C.25.3 LegalConstraints

XML Element / Name	Definition	Description	Multiplicity	Type
LegalConstraints Legal Constraints	A specification of restrictions and/or legal prerequisites for accessing and/or using either a resource or metadata about a resource.			Subclass of MD_LegalConstraints (Annex C.6.2)

XML Element / Name	Definition	Description	Multiplicity	Type
legalConstraintsDesc Legal Constraints Description	A description of restrictions and/or legal prerequisites for accessing and/or using either a resource or metadata about a resource.	For example, 'Distribution and use restricted to DoD/Title 50 and Coalition Forces.' Some commercial data is copyrighted. For example, 'Copyright 2000 Space Imaging, Inc.', in which case the copyright information for use of such imagery needs to be stated; this generally includes restrictions on use and distribution. For non copyright data, for example 'Copyright 2004 by the National Geospatial-Intelligence Agency, U.S. Government. No domestic copyright claimed under Title 17 U.S.C. All rights reserved.' A copyright is 'the exclusive legal right to reproduce, publish, and sell the matter and form.' 1) The foundation of the copyright is US law and international treaties. A [distribution] license (a.k.a. License Agreement) is the 'official or legal permission to do or own a specific thing.' 2) The licenses are part of the government contracts with the commercial data providers. The license delineates what the user may or may not do with the commercial product.	0..1	<<DataType>> CharacterString

C.25.4 ResourceConstraints

XML Element / Name	Definition	Description	Multiplicity	Type
ResourceConstraints Resource Constraints	Restrictions on the access to and/or use of a resource or a set of resource metadata information.	Restrictions may take the form of handling restrictions imposed on a resource or metadata associated with a resource because of national security and/or other security concerns.		Subclass of MD_Constraints (Annex C.6.1)
metadataStandard Metadata Standard Reference	A standardized reference for a standard (or specification) which determines the structure and content of a set of metadata.	This is the means by which the version of a metadata standard (Information Security Markings or NSG Metadata Foundation for example) used by the metadata would be indicated.	0..*	<<DataType>> CI_Citation (Annex C.5.2)
needToKnow Need-To-Know Access	Information used to facilitate automated access determination for a resource, based on system-specific properties assigned to the resource.	A resource may have multiple occurences in order to specify information from multiple, different access systems.	0..*	<<DataType>> NTKAccess
resCuiCategory Resource Controlled Unclassified Information Category	A categorical designation of the content of a resource that refers to unclassified information that does not meet the standards for National Security Classification under Executive Order 12958, as amended, but is (i) pertinent to the national interests of the United States or to the important interests of entities outside the Federal Government, and (ii) under law or policy requires protection from unauthorized disclosure, special handling safeguards, or prescribed limits on exchange or dissemination.	The designation 'Controlled Unclassified Information' (CUI) replaces the former designation 'Sensitive But Unclassified' (SBU).	0..1	<<Enumeration>> RestrictionInfoResCuiCategoryType (Annex C.25.5)

XML Element / Name	Definition	Description	Multiplicity	Type
resCuiSpecifiedDissem Resource Controlled Unclassified Information Specified Dissemination	Explanatory text specifying additional instructions on what dissemination is permitted for resource material identified as Controlled Unclassified Information (CUI).		0..1	<<DataType>> CharacterString
@classification Resource Classification	The highest level of classification applicable to an information resource or portion within the domain of classified national security information.	The Classification element is always used in conjunction with the Owner-Producer element. Taken together, the two elements specify the classification category and the type of classification (US, non-US, or Joint). See the Intelligence Community Technical Specification: Access Control Encoding Specification for Information Security Markings version 2 (9 May 2014) for details.	1	<<DataType>> ResClassificationStrucText (Annex D.14.2)
@ownerProducer Resource Owner-Producer	One or more indicators identifying the national government or international organization that have purview over the classification marking of an information resource or portion therein.	This element may contain North Atlantic Treaty Organization Special Words. It is always used in conjunction with the Resource Classification element. When taken together, the two elements specify the classification category and the type of classification (US, non-US, or Joint). See the Intelligence Community Technical Specification: Access Control Encoding Specification for Information Security Markings version 2 (9 May 2014) for details.	1	<<DataType>> ResOwnerProducerStrucText (Annex D.14.6)
@disseminationControls Resource Dissemination Controls	One or more indicators identifying the expansion or limitation on the distribution of an information resource.		0..1	<<DataType>> ResDissemControlsStrucText (Annex D.14.4)
@releasableTo Resource Releasable To	One or more indicators identifying the country or countries and/or international organization(s) to which classified resource information may be released based on the determination of an originator in accordance with established foreign disclosure procedures.	This element may contain North Atlantic Treaty Organization Special Words. It is used in conjunction with the Resource Dissemination Controls element.	0..1	<<DataType>> ResReleasableToStrucText (Annex D.14.7)
@displayOnlyTo Resource Display Only To	One or more indicators identifying the country or countries and/or international organization(s) to which classified information may be displayed based on the determination of an originator in accordance with established foreign disclosure procedures.	This element is used in conjunction with the Dissemination Controls element.	0..1	<<DataType>> CharacterString

XML Element / Name	Definition	Description	Multiplicity	Type
@nonICmarkings Resource Non-Intelligence Community Markings	One or more indicators of the expansion or limitation on the distribution of an information resource or portion within the domain of information originating from non-intelligence components.	This element may contain North Atlantic Treaty Organization Special Words.	0..1	<<DataType>> ResNonIntelComMarkingsStrucText (Annex D.14.5)
@SCIcontrols Resource SCI Controls	One or more indicators identifying sensitive compartmented information control system(s) applicable to the information resource.		0..1	<<DataType>> ResSciControlsStrucText (Annex D.14.8)
@derivedFrom Resource Derived From	A citation of the authoritative source(s) or reference to 'Multiple Sources' of the classification markings used in a classified information resource.		0..1	<<DataType>> CharacterString
@compilationReason Resource Compilation Reason	The reason that a portion or resource is marked with a higher and/or more restrictive mark than its components would indicate.	For example, this would document why 3 Unclassified bullet items form a Secret List. Without this reason being noted, such a document would be considered to be mismarked and over-classified.	0..1	<<DataType>> CharacterString
@classificationReason Resource Classification Reason	One or more reason indicators or explanatory text describing the basis for an original classification decision regarding an information resource.		0..1	<<DataType>> CharacterString
@classifiedBy Resource Classified By	The identity, by name or personal identifier, and position title of the original classification authority for the information resource.		0..1	<<DataType>> CharacterString
@derivativelyClassifiedBy Resource Derivatively Classified By	The identity, by name or personal identifier, of the derivative classification authority of an information resource.		0..1	<<DataType>> CharacterString
@declassDate Resource Declassification Date	A specific year, month, and day upon which the information resource shall be automatically declassified if not properly exempted from automatic declassification.		0..1	<<DataType>> ResDeclassDateStrucText (Annex D.14.3)
@declassEvent Resource Declassification Event	A description of an event upon which the information resource shall be automatically declassified if not properly exempted from automatic declassification.		0..1	<<DataType>> CharacterString

XML Element / Name	Definition	Description	Multiplicity	Type
Role: notice Security Notice	Information concerning well-defined security notice.	Examples of "well-defined" Notices include those dealing with the Foreign Intelligence Surviellance Act (FISA), US Persons, and Department of Defense (DoD) Distribution.	0..*	NoticeType (Annex C.26.1)

C.25.5 RestrictionInfoResCuiCategoryType

XML Element / Name	Definition	Description	Type
RestrictionInfoResCuiCategoryType Restriction Information Resource CUI Category Type	A coded domain value denoting the resource CUI category type of a restriction information entity.		<<Enumeration>>
controlledEnhancedSpecified Controlled Enhanced with Specified Dissemination	The information requires safeguarding measures more stringent than those normally required since the inadvertent or unauthorized disclosure would create risk of substantial harm, and the material contains additional instructions on what dissemination is permitted.	'Specified Dissemination' is a handling instruction that means the information so designated is subject to additional instructions governing the extent to which dissemination is permitted.	
controlledSpecified Controlled with Specified Dissemination	The information requires safeguarding measures that reduce the risks of unauthorized or inadvertent disclosure, and the material contains additional instructions on what dissemination is permitted.	'Specified Dissemination' is a handling instruction that means the information so designated is subject to additional instructions governing the extent to which dissemination is permitted.	
controlledStandard Controlled with Standard Dissemination	The information requires standard safeguarding measures that reduce the risks of unauthorized or inadvertent disclosure; dissemination is permitted to the extent that it is reasonably believed that it would further the execution of a lawful or official purpose.	'Standard Dissemination' is a handling instruction that means dissemination is authorized to the extent it is reasonably believed that dissemination would further the execution of lawful or official mission purpose, provided that individuals disseminating this information do so within the scope of their assigned duties.	

C.26 IC – Information Security Marking

C.26.1 NoticeType

XML Element / Name	Definition	Description	Multiplicity	Type
NoticeType Notice (IC DES)	Information concerning security notice(s) as determined by the Intelligence Community (IC) XML Data Encoding Specification (DES) for Information Security Marking (ISM) Metadata standard (IC DES.ISM.XML).			

XML Element / Name	Definition	Description	Multiplicity	Type
NoticeText Notice Content	The textual content of a security-related notice, including point-of-contact information.	For example: “This document contains RESTRICTED DATA as defined in the Atomic Energy Act of 1954. Unauthorized disclosure subject to administrative and criminal sanctions.”	1..*	<<DataType>> NoticeTextType (Annex C.26.2)
@noticeType Notice Type	The category of a security-related notice based on the nature of the restriction or warning to which it relates, as defined by the Intelligence Community (IC) XML Data Encoding Specification (DES) for Information Security Marking (ISM) Metadata standard (IC DES.ISM.XML).	Examples may include: the North Atlantic Treaty Organization (NATO), Restricted Data (RD), Formerly Restricted Data (FRD), and Foreign Intelligence Surveillance Act (FISA).	0..1	<<CodeList>> NoticeTypeCodeList (Annex D.14.1)
@noticeReason Notice Reason	A justification for controlling the release of information.	The text of the reason should be less than 2048 characters. An example includes the reason for a Department of Defense Distribution restriction.	0..1	<<DataType>> CharacterString
@noticeDate Notice Date	A date associated with a notice.	For example, a DoD Distribution notice date.	0..1	<<DataType>> Date
@unregisteredNoticeType Notice Type Unregistered	The category of a security-related notice based on the nature of the restriction or warning to which it relates, where that category is not included in the Intelligence Community (IC) XML Data Encoding Specification (DES) for Information Security Marking (ISM) Metadata standard (IC DES.ISM.XML).	The text of the Notice Type must be less than 2048 characters.	0..1	<<DataType>> CharacterString
@externalNotice Notice External	An indication that the information requiring the security-related notice is not present in the resource.	This indicator allows for a security-related notice to exist through association with a resource, but without the data that would normally require the notice. A citation may be accompanied by a notice applicable to the cited content, but not the citation itself.	0..1	Boolean
@classification Resource Classification	The highest level of classification applicable to an information resource or portion within the domain of classified national security information.	The Classification element is always used in conjunction with the Owner-Producer element. Taken together, the two elements specify the classification category and the type of classification (US, non-US, or Joint). See the Intelligence Community Technical Specification: Access Control Encoding Specification for Information Security Markings version 2 (9 May 2014) for details.	1	<<DataType>> ResClassificationStrucText (Annex D.14.2)

XML Element / Name	Definition	Description	Multiplicity	Type
@ownerProducer Resource Owner-Producer	One or more indicators identifying the national government or international organization that have purview over the classification marking of an information resource or portion therein.	This element may contain North Atlantic Treaty Organization Special Words. It is always used in conjunction with the Resource Classification element. When taken together, the two elements specify the classification category and the type of classification (US, non-US, or Joint). See the Intelligence Community Technical Specification: Access Control Encoding Specification for Information Security Markings version 2 (9 May 2014) for details.	1	<<DataType>> ResOwnerProducerStrucText (Annex D.14.6)
@disseminationControls Resource Dissemination Controls	One or more indicators identifying the expansion or limitation on the distribution of an information resource.		0..1	<<DataType>> ResDissemControlsStrucText (Annex D.14.4)
@releasableTo Resource Releasable To	One or more indicators identifying the country or countries and/or international organization(s) to which classified resource information may be released based on the determination of an originator in accordance with established foreign disclosure procedures.	This element may contain North Atlantic Treaty Organization Special Words. It is used in conjunction with the Resource Dissemination Controls element.	0..1	<<DataType>> ResReleasableToStrucText (Annex D.14.7)

C.26.2 NoticeTextType

XML Element / Name	Definition	Description	Multiplicity	Type
NoticeTextType Notice Content Type (IC DES)	The text of a security notice as determined by the Intelligence Community (IC) XML Data Encoding Specification (DES) for Information Security Marking (ISM) Metadata standard (IC DES.ISM.XML).	A security notice may contain point-of-contact information for a party responsible for the content of the notice.		<<DataType>> Subclass of <<DataType>> CharacterString
@pocType Notice Point Of Contact Type	A reason for a party who is responsible for a security-related notice.	Certain points-of-contact (POCs) are required for different reasons, such as Intelligence Community Directive (ICD)-710, “Classification Management and Conrol Markings System” compliance or Department of Defense (DoD) Distribution statements. An external source of valid values for Notice Point Of Contact Type is the XML Schema named CVEnumISMPocType.xsd.	0..1	<<CodeList>> NoticeTypeCodeList (Annex D.14.1)

XML Element / Name	Definition	Description	Multiplicity	Type
@classification Resource Classification	The highest level of classification applicable to an information resource or portion within the domain of classified national security information.	The Classification element is always used in conjunction with the Owner-Producer element. Taken together, the two elements specify the classification category and the type of classification (US, non-US, or Joint). See the Intelligence Community Technical Specification: Access Control Encoding Specification for Information Security Markings version 2 (9 May 2014) for details.	1	<<DataType>> ResClassificationStrucText (Annex D.14.2)
@ownerProducer Resource Owner-Producer	One or more indicators identifying the national government or international organization that have purview over the classification marking of an information resource or portion therein.	This element may contain North Atlantic Treaty Organization Special Words. It is always used in conjunction with the Resource Classification element. When taken together, the two elements specify the classification category and the type of classification (US, non-US, or Joint). See the Intelligence Community Technical Specification: Access Control Encoding Specification for Information Security Markings version 2 (9 May 2014) for details.	1	<<DataType>> ResOwnerProducerStrucText (Annex D.14.6)
@disseminationControls Resource Dissemination Controls	One or more indicators identifying the expansion or limitation on the distribution of an information resource.		0..1	<<DataType>> ResDissemControlsStrucText (Annex D.14.4)
@releasableTo Resource Releasable To	One or more indicators identifying the country or countries and/or international organization(s) to which classified resource information may be released based on the determination of an originator in accordance with established foreign disclosure procedures.	This element may contain North Atlantic Treaty Organization Special Words. It is used in conjunction with the Resource Dissemination Controls element.	0..1	<<DataType>> ResReleasableToStrucText (Annex D.14.7)

Annex D NEMIS Codelist and Structured Text Values

D.1 Introduction

The NEMIS logical metadata model is specified using Unified Modeling Language (UML ISO/IEC 19505). Information elements are specified in terms of classes (information modeling entities), their properties (*e.g.*, a property named “Length” whose range is represented using the data type ”Real” and which may have the specific value ”82.4”), and for each the allowed range of property values. This Annex tabularly presents a textual specification of the UML property value ranges that appear in UML class diagrams in Annex BAnnex D where there is a limited set of allowed values in the NEMIS.

The allowed range of a property value may be specified by either listing each of the allowed values in the case that the list is of manageable length (*e.g.*, “column” and “row”), or by specifying a pattern of allowed values in the case that those values follow some algorithmic relationship (*e.g.*, all string values whose length is exactly 10 characters and both start and end with the letter “A”). In the former case, the datatype involved uses the UML stereotype <<Enumeration>> if the set of allowed values is fixed in the model, or <<CodeList>> if the set is determined external to the model and may be revised independent of revision to the model.

Management of <<CodeList>> types is often accomplished through registration of allowed values as a net-accessible resource. NGA has established such a register: https://nsgreg.nga.mil/ir/registers.jsp?register=CLST

In the case of a set of allowed values that is determined by a pattern, then a “Structured Text” datatype is used that includes a specification of the pattern of the structuring of allowed values.

This Annex documents both Codelists and Structured Text datatypes used in the NEMIS metadata model.

The style of tables documenting <<CodeList>> and “Structured Text” types follows that of the NSG Metadata Foundation (NGA.STND.0012_3.0_NMF), with one important exception. The NEMIS logical metadata model is accompanied by an XSD-based specification for use in validation of XML instance documents and in some cases the naming of XSD elements and datatypes in external standards (*e.g.*, the ISO 19100 series) differs from that used in the NAS (thus NMF) logical data model.

Since emphasis is placed in the NEMIS on its XSD-based specification, where applicable the name of UML classes and/or properties as they appear in the following tables will differ from the corresponding data dictionary tables in the NMF. Instead, those names align with the content of the XSD-based encoding of the NMF, the NSG Metadata Implementation Specification (NGA.STND.0018_3.0_NMIS).[1]

These tables are organized thematically, in alignment with the UML class diagrams in Annex B.

- Commonly Used Codelists
- Citation and Responsible Party Information Codelists

[1] The same proviso regarding renaming applies in the corresponding UML class diagrams in Annex B.

- Constraint Information Codelists
- Identification Information Codelists
- Language-characterset Localisation Information Codelists
- Maintenance Information Codelists
- Coordinate Reference System Information Resources and Codelists
- Spatial Representation Information Codelists
- Imagery Acquisition Information Codelists
- NAS – Entity Metadata Structured Text and Codelists
- NAS – General Datatype Codelists
- NAS – Resource Metadata Codelists
- IC - Information Security Marking Codelist and Structured Text Values

Documentation of <<CodeList>> and “Structured Text” datatypes is organized as follows:

- Each datatype is documented by a unique table whose first row characterizes the datatype itself and whose remaining rows in the case of a <<CodeList>> characterize its allowed values. To emphasize this distinction the row characterizing the datatype itself is presented with a light-gray fill.
- Each listed value for a <<CodeList>> datatype is documented on a separate row.

Each datatype and listed value is specified on the basis of a set of well-known characteristics; the set of characteristics will vary by the type of element. The information presented on each row is specified in Table D-1.

Table D-1. Datatype element definitions

Column	Purpose
XML Value	A textual value that is used to denote the datatype or listed value in data interchange. This corresponds to the XML element name specified by the NEMIS XSD, rather than the UML name in the NMF or NAS.
Name	A compact and human-readable designator that is used to denote the datatype or listed value.
Definition	A precise statement of the nature, properties, scope, or essential qualities of the datatype or listed value.
Description	A statement of the nature, properties, scope, or non-essential qualities of the datatype or listed value that are not specified by the definition.
Structure Specification	(Structured Text only) A scheme of one or more constraints on the structure of allowed text values.

Note that in the case of some <<CodeList>> datatypes the listed (allowed) values have been restricted from the full ISO, NAS, or IC codelist in order to ensure conformance to elevation datatypes, reduce ambiguity, and facilitate the interchange of data across software platforms and search tools.

D.2 Commonly Used Codelists

D.2.1 MD_ScopeCode

XML Value	Name	Definition	Description
MD_ScopeCode	Resource Scope Codelist	A codelist, each domain member of which denotes a grouping of information within a resource.	A scope identifies a grouping of information within a resource. Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) MD_ScopeCode.
dataset	Application	The information resource hosted on a specific set of hardware and accessible over a network.	
attribute	Attribute	The information applies to the attribute value.	
collection	Collection	The information applies to an unstructured set.	
coverage	Coverage	The information applies to a data coverage.	
dataset	Dataset	The information applies to the dataset.	
document	Document	The information applies to a document.	
feature	Feature	The information applies to a feature.	A feature is an abstraction of real world phenomena.
metadata	Metadata	The information applies to metadata.	
model	Model	The information applies to a copy or imitation of an existing or hypothetical object.	
product	Product	The information applies to an ISO 19131-conformant data product specification.	For example, metadata describing the data product specification.
series	Series	The information applies to the series.	A series is a set of related resources (for example: datasets) that share common metadata (for example: theme, source date, resolution, and methodology). For example, a series of vector datasets, each of which depict surface hydrography with associated attributes.
software	Software	The information applies to a computer program or routine.	
tile	Tile	The information applies to a tile, a spatial subset of geographic data.	

For NEMIS metadata, these are the only valid values in the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/ScopeCode

D.3 Citation and Responsible Party Information Codelists

D.3.1 CI_DateTypeCode

XML Value	Name	Definition	Description
CI_DateTypeCode	Date Type Codelist	A codelist, each domain member of which denotes a type of event for which a date is specified.	A date type indicates the nature of the event indicated by a date. Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) CI_DateTypeCode.
creation	Creation	The date identifies when the resource was brought into existence.	
distribution	Distribution	The date identifies when the resource was in distribution (for example: available for retail sale).	
publication	Publication	The date identifies when the resource was published (issued).	
revision	Revision	The date identifies when the resource was examined or re-examined and improved or amended.	
superseded	Superseded	The date identifies when the resource was superseded or replaced by another resource.	

For NEMIS metadata, these are the only valid values in the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/DateTypeCode

D.3.2 CI_OnLineFunctionCode

XML Value	Name	Definition	Description
CI_OnLineFunctionCode	Online Function Codelist	A codelist, each domain member of which denotes a function performed by an online resource.	An online function indicates a function performed by a resource. Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) CI_OnLineFunctionCode.
browseGraphic	Browse Graphic	A resource browse graphic is provided.	
completeMetadata	Complete Metadata	Complete resource metadata is provided.	
download	Download	Online instructions are provided for transferring data from one storage device or system to another.	For example, from the resource provider to the user.
information	Information	Online information is provided about the resource.	
order	Order	An online order process is provided for obtaining the resource.	
search	Search	An online search interface is provided for seeking out information about the resource.	

For NEMIS metadata, these are the only valid values in the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/OnlineFunctionCode

D.3.3 CI_RoleCode

XML Value	Name	Definition	Description
CI_RoleCode	Resource Role Codelist	A codelist, each domain member of which denotes a function performed by the party responsible for a resource.	A role identifies a function performed by a responsible party. Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) CI_RoleCode.
contributor	Contributor	A party contributing to the resource.	
distributor	Distributor	A party who distributes the resource.	Corresponds in use to DateTypeCode::distribution.
editor	Editor	A party who reviewed or modified the resource to improve the content.	
originator	Originator	A party who originated (created) the resource.	Corresponds in use to DateTypeCode::creation.
owner	Owner	A party who owns the resource.	
pointOfContact	Point of Contact	A party who can be contacted for acquiring knowledge about, or acquisition of, the resource.	
publisher	Publisher	A party who published the resource.	Corresponds in use to DateTypeCode::publication.
user	User	The party uses the resource.	

For NEMIS metadata, these are the only valid values in the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/RoleCode

D.3.4 CI_TelephoneTypeCode

XML Value	Name	Definition	Description
CI_TelephoneTypeCode	Telephone Type Codelist	A codelist, each domain member of which denotes the name of a telephone communication mode.	Examples include voice or facsimile. Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) CI_TelephoneTypeCode.
facsimile	Facsimile	The telephone supports facsimile service, a system of sending and reproducing printed matter or pictures by means of signals sent over telephone lines.	
voice	Voice	The telephone supports voice service.	

For NEMIS metadata, these are the only valid values in the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/TelephoneTypeCode

D.4 Constraint Information Codelists

D.4.1 MD_RestrictionCode

XML Value	Name	Definition	Description
MD_RestrictionCode	Restriction Codelist	A codelist, each domain member of which denotes a limitation placed upon the access to, or use of, a resource.	A restriction identifies a limitation placed upon the access to, or use of, a resource. Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) MD_RestrictionCode.
confidential	Confidential	The resource is not available to the public as it contains information that could be prejudicial to a commercial, industrial, or national interest.	
copyright	Copyright	The resource is under protection against reproduction and/or distribution without the express written permission of the copyright owner.	A copyright is the exclusive right to the publication, production, and/or sale of the rights to a literary, dramatic, musical, and/or artistic work, or to the use of a commercial print and/or label, that is granted by law for a specified period of time.
inConfidence	In Confidence	The resource is disclosed confidentially, based on mutual trust.	
intellectualPropertyRights	Intellectual Property Rights	The resource is under protection against reproduction and/or distribution without the express written permission of the intellectual property rights owner.	While copyright is considered a type of intellectual property right, in this instance copyright should be indicated separately, and intellectual property rights shall be used to indicate all other intellectual rights other than copyrights.
licence	Licence	The resource is protected by formal permission from an authority.	
licenceDistributor	Licence Distributor	Formal permission is required for a person or an entity to commercialize or distribute the resource.	
licenceEndUser	Licence End-user	Formal permission is required to use the resource, and may differ from the permissions granted the person or entity that orders or purchases it.	
licenceUnrestricted	Licence Unrestricted	Formal permission is not required to use the resource.	
otherRestrictions	Other Restrictions	The resource is restricted in a manner not elsewhere specified.	
patent	Patent	The resource is under the protection of a government-granted exclusive right to make, sell, use or license an invention or discovery.	

XML Value	Name	Definition	Description
patentPending	Patent Pending	The resource is produced or sold while awaiting the protection of a government-granted exclusive right to make, sell, use or license an invention or discovery.	
private	Private	The resource is protected by the rights of individual or organisations to be free from observation, intrusion, or attention of others.	
restricted	Restricted	The resource is withheld from general circulation or disclosure.	
sensitiveButUnclassified	Sensitive But Unclassified	The resource, although unclassified, requires strict controls over its distribution.	
statutory	Statutory	The resource is under protections prescribed by law.	
trademark	Trademark	The resource includes a protected name, symbol, or other device identifying a product, officially registered and legally restricted to the use of the owner or manufacturer.	
unrestricted	Unrestricted	There are no limitations placed upon the access to, or use of, the resource	

XML Value	Name	Definition	Description
usPrivacyAct	U.S. Privacy Act	The resource is categorized as containing personal information subject to protection by the (U.S.) Privacy Act of 1974 (as subsequently amended), being Title 5 of the United States Code, Section 552a.	The act states, in part, that no agency shall disclose any record which is contained in a system of records by any means of communication to any person, or to another agency, except pursuant to a written request by, or with the prior written consent of, the individual to whom the record pertains, unless disclosure of the record would be: (1) to those officers and employees of the agency which maintains the record who have a need for the record in the performance of their duties; (2) required under section 552 of this title; (3) for a routine use as defined in subsection (a)(7) of this section and described under subsection (e)(4)(D) of this section; (4) to the Bureau of the Census for purposes of planning or carrying out a census or survey or related activity pursuant to the provisions of title 13; (5) to a recipient who has provided the agency with advance adequate written assurance that the record will be used solely as a statistical research or reporting record, and the record is to be transferred in a form that is not individually identifiable; (6) to the National Archives and Records Administration as a record which has sufficient historical or other value to warrant its continued preservation by the United States Government, or for evaluation by the Archivist of the United States or the designee of the Archivist to determine whether the record has such value; (7) to another agency or to an instrumentality of any governmental jurisdiction within or under the control of the United States for a civil or criminal law enforcement activity if the activity is authorized by law, and if the head of the agency or instrumentality has made a written request to the agency which maintains the record specifying the particular portion desired and the law enforcement activity for which the record is sought; (8) to a person pursuant to a showing of compelling circumstances affecting the health or safety of an individual if upon such disclosure notification is transmitted to the last known address of such individual; (9) to either House of Congress, or, to the extent of matter within its jurisdiction, any committee or subcommittee thereof, any joint committee of Congress or subcommittee of any such joint committee; (10) to the Comptroller General, or any of his authorized representatives, in the course of the performance of the duties of the Government Accountability Office; (11) pursuant to the order of a court of competent jurisdiction; or (12) to a consumer reporting agency in accordance with section 3711(e) of title 31.

Drawn from the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/RestrictionCode

D.5 Identification Information Codelists

D.5.1 MD_KeywordTypeCode

XML Value	Name	Definition	Description
MD_KeywordTypeCode	Keyword Type Codelist	A codelist, each domain member of which denotes the method used to group a set of similar keywords.	A keyword type indicates the method used to group a set of similar keywords. Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) MD_KeywordTypeCode.
dataCentre	Data Centre	The keyword identifies a a repository or archive that manages and distributes data.	
discipline	Discipline	The keyword identifies a branch of instruction or specialized learning.	
featureType	Feature Type	The keyword identifies a resource containing or about a collection of feature instances with common characteristics.	
instrument	Instrument	The keyword identifies a device used to measure or compare physical properties.	
place	Place	The keyword identifies a location.	
platform	Platform	The keyword identifies a structure upon which an instrument is mounted.	
process	Process	The keyword identifies a series of actions or natural occurrences.	
product	Product	The keyword identifies a type of product.	
project	Project	The keyword identifies an endeavour undertaken to create or modify a product or service.	
service	Service	The keyword identifies an activity carried out by one party for the benefit of another.	
stratum	Stratum	The keyword identifies the layer(s) of any deposited substance or levels within an ordered system.	
subTopicCategory	Sub-topic Category	The keyword refines a topic category for the purpose of geographic data classification.	
taxon	Taxon	The keyword identifies a taxonomy of the resource.	
temporal	Temporal	The keyword identifies a time period related to the resource.	
theme	Theme	The keyword identifies a particular subject or topic.	

Drawn from the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/KeywordTypeCode

D.5.2 MD_ProgressCode

XML Value	Name	Definition	Description
MD_ProgressCode	Resource Progress Codelist	A codelist, each domain member of which denotes a status of the dataset or progress of a review.	A resource progress status identifies the status of the dataset or progress of a review. Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) MD_ProgressCode.
completed	Completed	Production of the data has been completed.	
final	Final	Progress has concluded and no changes will be accepted.	
historicalArchive	Historical Archive	Data has been stored in an offline storage facility.	
obsolete	Obsolete	Data is no longer relevant.	
onGoing	On-going	Data is continually being updated.	
proposed	Proposed	Proposed that development needs to be undertaken.	
underDevelopment	Under Development	Data is currently in the process of being created.	

For NEMIS metadata, these are the only valid values in the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/ProgressCode

D.5.3 MD_SpatialRepresentationTypeCode

XML Value	Name	Definition	Description
MD_SpatialRepresentationTypeCode	Spatial Representation Type Codelist	A codelist, each domain member of which denotes a method used to represent geospatial information in a resource.	A spatial representation type identifies a method used to represent geospatial information in a resource. Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) MD_SpatialRepresentationTypeCode.
grid	Grid	Grids are used to represent geospatial data.	
pointCloud	Point Cloud	A collection of data points in three-dimensional space is used to represent geospatial data.	A collection of points in space is often called a "cloud". Point clouds are generally produced by three-dimensional scanners (for example: Light Detection and Ranging (LiDAR)), which measure a large number of points on the external surfaces of objects or the surface of the earth.
threeDimensionalModel	Three-dimensional Model	A three-dimensional model is used to represent geospatial data.	For example: the three-dimensional model may represent features (abstractions of real-world phenomena).

XML Value	Name	Definition	Description
stereoModel	Stereo Model	Three-dimensional views formed by the intersecting homologous rays of an overlapping pair of images is used to represent geospatial data.	
tin	Tin	Triangulated irregular network is used to represent geospatial data.	
vector	Vector	Vectors are used to represent geospatial data.	

For NEMIS metadata, these are the only valid values in the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/SpatialRepresentationTypeCode

D.5.4 MD_TopicCategoryCode

XML Value	Name	Definition	Description
MD_TopicCategoryCode	Topic Category Code	A coded domain value denoting a high-level geographic data thematic classification that assists in the grouping and search of available geospatial data sets.	May be used to group keywords as well. The listed examples are not exhaustive. It is understood there are overlaps between general categories and the user is encouraged to select the one most appropriate.
elevation	Elevation	height above or below sea level	Examples: altitude, bathymetry, digital elevation models, slope, derived products.

For NEMIS metadata, this is the only valid value in the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/TopicCategory

D.6 Language-characterset Localisation Information Codelists

D.6.1 LanguageCode

XML Value	Name	Definition	Description
LanguageCode	ISO 639-2 Trigraph Language Codelist	The set of ISO 639-2 (Codes for the representation of names of languages - Part 2: Alpha-3 code) trigraph (3-letter) codes for the representation of the names of languages.	While most languages are given one code by the standard, twenty of the languages specified have two three-character codes, a "bibliographic" code (ISO 639-2/B), which is derived from the English name for the language and was a necessary legacy feature, and a "terminological" code (ISO 639-2/T), which is derived from the native name for the language.
eng	English		

NEMIS metadata shall be distributed in English. For resource data from foreign sources, consult the set of ISO 639-2 trigraph codes in the NSG Standards Registry codelist: https://api.nsgreg.nga.mil/codelist/ISO639-2

D.6.2 CountryCode

XML Value	Name	Definition	Description
CountryCode	GENC Short URN-based Identifier	The short URN-like Uniform Resource Identifier (URI) for a geopolitical entity (for example: a State) or administrative subdivision (for example: a province) as specified by the Geopolitical Entities, Names, and Codes (GENC) Standard.	The GENC Standard specifies a profile of ISO 3166, Codes for the representation of names of countries and their subdivisions; that profile addresses unique U.S. Government requirements for: restrictions in recognition of the national sovereignty of a country; identification and recognition of geopolitical entities not included in ISO 3166; and the use of names of countries and country subdivisions that have been approved by the U.S. Board on Geographic Names.
ge:GENC:3:3-11:USA	United States of America		

For elevation data from foreign sources, use the GENC content discovery tool: https://nsgreg.nga.mil/genc

D.6.3 IANACharset

XML Value	Name	Definition	Description
IANACharset	IANA Charset Codelist	The set of charsets recognized through the Internet Assigned Numbers Authority (IANA) registration procedure established by RFC 2978 (IANA Charset Registration Procedures); a charset (referred to as a "character set" in the past) is a method of converting a sequence of octets into a sequence of characters, optionally producing additional control information such as directionality indicators.	The charset registration procedure exists solely to associate a specific name or names with a given charset and to give an indication of whether or not a given charset can be used in MIME text objects. The results of registration are documented at http://www.iana.org/assignments/character-sets and were last updated 2007-05-14 (further information is published at: http://www.iana.org/protocols/). Members of the set are drawn from the multi-part ISO/IEC 8859 (Information technology - 8-bit single-byte coded graphic character sets), ISO/IEC 10646 (Information technology - Universal multiple-octet coded character set (UCS)), and other sources.
UTF-8	UTF-8	The 8-bit variable size UCS Transfer Format charset that is based on ISO/IEC 10646, as specified by the Internet Engineering Task Force (IETF) Request For Comment (RFC) 2152.	MIBenum value = 106. Reference: Yergeau, F., "UTF-8, a transformation format of ISO 10646", RFC3629, November 2003.

NEMIS metadata should be formatted in the UTF-8 charset for maximum compatibility. For resource data from foreign sources, consult the set of charsets in the NSG Standards Registry codelist: https://api.nsgreg.nga.mil/codelist/IANACharset

D.7 Maintenance Information Codelists

D.7.1 MD_MaintenanceFrequencyCode

XML Value	Name	Definition	Description
MD_MaintenanceFrequencyCode	Maintenance Frequency Codelist	A codelist, each domain member of which denotes a maintenance frequency.	A maintenance frequency code indicates the frequency with which modifications and deletions are made to the data after it is first produced. Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) MD_MaintenanceFrequency).
continual	Continual	The resource is repeatedly and frequently updated.	
daily	Daily	The resource is updated each day.	
weekly	Weekly	The resource is updated on a weekly basis.	
monthly	Monthly	The resource is updated each month.	
quarterly	Quarterly	The resource is updated every three months.	
biannually	Biannually	The resource is updated twice each year.	
annually	Annually	The resource is updated every year.	
asNeeded	As Needed	The resource is updated as deemed necessary.	
irregular	Irregular	The resource is updated in intervals that are uneven in duration.	
notPlanned	Not Planned	There are no plans to update the resource.	
unknown	Unknown	The frequency of maintenance for the resource is not known.	

For NEMIS metadata, these are the only valid values in the NSG Standards Registry codelist:
http://api.nsgreg.nga.mil/codelist/MaintenanceFrequencyCode

D.8 Coordinate Reference System Information Resources and Codelists

D.8.1 Coordinate Reference Systems

The NGA National Center for Geospatial Intelligence Standards (NCGIS) maintains a set of Coordinate Reference System (CRS) information resources in the NSG Standards Registry. They may be accessed at:

http://nsgreg.nga.mil/ir/registers.jsp?register=SRS

NEMIS XML instance documents should only use those CRS that have been registered in this component of the NSG Standards Registry. Registered CRS are identified by URIs composed from the **~/coord-ref-system/** base URL plus a short CRS-specific identifier. For example, in the case of the World Geodetic System 1984 - Geographic, 2-Dimensional CRS, this identification is by the URI:

http://api.nsgreg.nga.mil/coord-ref-system/WGS84E_2D

Each URI has a corresponding CRS-specific accessible information resource whose content may be directly accessed by Internet-connected applications via a REpresentational State Transfer (REST) API. The NSG Standards Registry information resource encodes a detailed specification for each registered CRS as an XML instance document using XML elements and types specified in ISO 19136:2007 (GML) Clause 12.3 (Coordinate Reference Systems).

Specification of a CRS by reference to the NSG Standards Registry-hosted CRS information resources allows for dynamic support for coordinate reference systems in NEMIS XML instance documents. It also avoids the overhead of exchanging CRS specifications as part of individual NEMIS XML instance documents by instead promulgating well-known CRS identifiers (including those defined in NGA.STND.0036_1.0.0_WGS84) and their specifications in the DoD/IC. Additional CRS specifications may be added to the NSG Standards Registry by NGA upon request, provided their parameters are precisely known (*e.g.*, as part of an EPSG CRS definition).

D.8.2 MD_ReferenceSystemTypeCode

XML Value	Name	Definition	Description
MD_ReferenceSystemTypeCode	Reference System Type Codelist	A codelist, each domain member of which denotes a reference system type.	Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) MD_ReferenceSystemTypeCode.
geodeticGeocentric	Geodetic Geocentric	A geodetic coordinate reference system having a Cartesian 3-dimensional coordinate system.	For example: [geocentric] X, Y, Z.
geodeticGeographic2D	Geodetic Geographic 2D	A geodetic coordinate reference system having an ellipsoidal 2-dimensional coordinate system.	For example: latitude, longitude.
geodeticGeographic3D	Geodetic Geographic 3D	A geodetic coordinate reference system having an ellipsoidal 3-dimensional coordinate system.	For example: latitude, longitude, ellipsoidal height.
projected	Projected	A coordinate reference system derived from a two-dimensional geodetic coordinate reference system by applying a map projection.	For example: easting, northing.
vertical	Vertical	A one-dimensional coordinate reference system based on a vertical datum (datum describing the relation of gravity-related heights or depths to the Earth).	For example: [gravity-related] height or depth.

For NEMIS metadata, these are the only valid values in the NSG Standards Registry:
http://api.nsgreg.nga.mil/codelist/ReferenceSystemTypeCode

D.8.3 Coordinate Reference System Use

D.8.3.1 General Considerations

The CRS types specified in MD_ReferenceSystemTypeCode are drawn from the NSG Standards Registry codelist (http://api.nsgreg.nga.mil/codelist/ReferenceSystemTypeCode); this subset was selected for use with time-independent, geospatial elevation datasets.

Compound 3D coordinate systems (Geographic 2D/Vertical or Projected/Vertical) are not supported because the 'EX_Exent.geographicElement' and 'EX_Extent.verticalElement' attributes are independently specified using Geographic 2D and Vertical CRS URIs, respectively, in the NEMIS metadata model. Use of a Compound Geographic 2D Vertical CRS in place of its independent horizontal/vertical components is unnecessary and may introduce software compatibility issues.

Further guidance on the usage of each supported CRS type is provided in the following sections of this SIG.

D.8.3.2 Geodetic Geocentric

This coordinate system is also known as the Earth-Centered, Earth-Fixed (ECEF) coordinate system. It is a right-handed Cartesian (*x*, *y*, *z*) system, the origin of which is at the Earth's center of mass.

WGS84C_3D is the recommended reference system within the Geodetic Geocentric reference system type. It shall be in accordance with *World Geodetic System 1984 - Earth Centered, Earth Fixed (ECEF)*, as specified in NGA.STND.0036_1.0.0_WGS84 and identified by the URI:

http://api.nsgreg.nga.mil/coord-ref-system/WGS84C_3D

D.8.3.3 Geodetic Geographic 2D

The coordinate system is ellipsoidal and most commonly the datum will be World Geodetic System 1984 (WGS 84); however, other geodetic datums of limited geographic extent may be employed for particular purposes.

WGS84E_2D is the recommended reference system within the Geodetic Geographic 2D reference system type. It shall be in accordance with *World Geodetic System 1984 - Geographic 2D*, as specified in NGA.STND.0036_1.0.0_WGS84 and identified by the URI:

http://api.nsgreg.nga.mil/coord-ref-system/WGS84E_2D

An alternative Geodetic 2D CRS for a limited-extent geographic region may be used only if that CRS has been first registered in the NSG Standards Registry.

D.8.3.4 Geodetic Geographic 3D

The coordinate system is ellipsoidal. Most commonly the datum will be WGS 84; however, other geodetic datums of limited geographic extent may be employed for particular purposes. The third coordinate axis is perpendicular to the ellipsoid, positive upwards.

WGS84E_3D is the recommended reference system within the Geodetic Geographic 3D reference system type. It shall be in accordance with *World Geodetic System 1984 - Geographic 3D*, as specified in NGA.STND.0036_1.0.0_WGS84 and identified by the URI:

http://api.nsgreg.nga.mil/coord-ref-system/WGS84E_3D

An alternative Geodetic 3D CRS for a limited-extent geographic region or GPS broadcast ephemeris may be used only if that CRS has been first registered in the NSG Standards Registry.

D.8.3.5 Projected (2D)

The coordinate system is Cartesian, most commonly based on the Universal Transverse Mercator (UTM) or Universal Polar Stereographic (UPS) map projections. Most commonly the datum will be WGS 84; however, other geodetic datums of limited geographic extent may be employed for particular purposes.

The **WGS84E_UTM*** and **WGS84E_UPS*** CRS variants are the recommended reference systems within the Projected reference system type. They shall be the universal grids as specified in NGA.STND.0036_1.0.0_WGS84. UTM-based projected 2D CRS are identified by one of 120 URIs of the following form, where each of the 60 UTM zones is split into separate Northern Hemisphere and Southern Hemisphere grid zones:

http://api.nsgreg.nga.mil/coord-ref-system/WGS84E_UTM01N
http://api.nsgreg.nga.mil/coord-ref-system/WGS84E_UTM01S
…
http://api.nsgreg.nga.mil/coord-ref-system/WGS84E_UTM60N
http://api.nsgreg.nga.mil/coord-ref-system/WGS84E_UTM60S

UPS-based projected 2D CRS are identified by one of two URIs distinguished by the geographic pole at which the grid zone is specified:

http://api.nsgreg.nga.mil/coord-ref-system/WGS84E_UPSN
http://api.nsgreg.nga.mil/coord-ref-system/WGS84E_UPSS

D.8.3.6 Vertical (1D)

The coordinate system is one-dimensional, where the position of points is relative to a single straight axis normal to the geoid surface. For terrain datasets, the positive direction of that axis is upward; for bathymetric datasets, it is downward.

EGM08_H is the recommended reference system within the Vertical reference system type. This is the distance above the geopotential surface defined by the Earth Gravity Model 2008 (EGM2008), which is closely associated with the mean ocean surface. EGM2008 is specified in NGA.STND.0036_1.0.0_WGS84 and identified by the URI:

http://api.nsgreg.nga.mil/coord-ref-system/EGM08_H

D.9 Spatial Representation Information Codelists

D.9.1 MD_CellGeometryCode

XML Value	Name	Definition	Description
MD_CellGeometryCode	Cell Geometry Codelist	A codelist, each domain member of which denotes whether grid cells are based on either a point or area representation.	Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) MD_CellGeometryCode.
area	Area	Each cell represents an area.	
point	Point	Each cell represents a point.	

For NEMIS metadata, these are the only valid values in the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/CellGeometryCode

D.9.2 MD_DimensionNameTypeCode

XML Value	Name	Definition	Description
MD_DimensionNameTypeCode	Dimension Name Type Codelist	A codelist, each domain member of which denotes the name of a dimension.	Many members of the set are drawn from ISO 19115-1 (Geographic Information - Metadata - Part 1: Fundamentals) MD_DimensionNameTypeCode.
column	Column	Abscissa (x) axis.	
row	Row	Ordinate (y) axis.	

For NEMIS metadata, these are the only valid values in the NSG Standards Registry codelist:
http://api.nsgreg.nga.mil/codelist/DimensionNameTypeCode

D.10 Imagery Acquisition Information Codelists

D.10.1 MI_GeometryTypeCode

XML Value	Name	Definition	Description
MI_GeometryTypeCode	Geometry Type Codelist	A codelist, each domain member of which denotes a geometric description of the collection.	Many members of the set are drawn from ISO 19115-2 (Geographic Information - Metadata - Part 2: Extensions for acquisition and processing) MI_GeometryTypeCode.
point	Point	Single geographic point of interest.	
areal	Areal	Collection of a geographic area defined by a polygon (coverage).	

For NEMIS metadata, these are the only valid values in the NSG Standards Registry codelist:
http://api.nsgreg.nga.mil/codelist/GeometryTypeCode

D.10.2 MI_OperationTypeCode

XML Value	Name	Definition	Description
MI_OperationTypeCode	Operation Type Codelist	A codelist, each domain member of which denotes whether the data contained in this packet is real (originates from live-fly or other non-simulated operational sources), simulated (originates from target simulator sources), or synthesized (a mix of real and simulated data).	Many members of the set are drawn from ISO 19115-2 (Geographic Information - Metadata - Part 2: Extensions for acquisition and processing) MI_OperationTypeCode.
real	Real	Originates from live-fly or other non-simulated operational source.	
simulated	Simulated	Originates from target simulator sources.	
synthesized	Synthesized	Mix of real and simulated data.	

Drawn from the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/OperationTypeCode

D.10.3 MI_PriorityCode

XML Value	Name	Definition	Description
MI_PriorityCode	Priority Codelist	A codelist, each domain member of which denotes a member of the ordered list of priorities.	Many members of the set are drawn from ISO 19115-2 (Geographic Information - Metadata - Part 2: Extensions for acquisition and processing) MI_PriorityCode.
critical	Critical	Decisive importance.	
highImportance	High Importance	Requires resources to be made available.	
lowImportance	Low Importance	To be completed when resources are available.	
mediumImportance	Medium Importance	Normal operation priority.	

Drawn from the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/PriorityCode

D.11 NAS – Entity Metadata Structured Text and Codelists

D.11.1 FeatureExtractSoftwareCodeList

XML Value	Name	Definition	Description
FeatureExtractSoftwareCodeList	Feature Extraction Software Codelist	A codelist, each domain member of which denotes a feature extraction software.	The software process used to derive features from an image source. Electronic Light Table (ELT) software, for example, may implement different algorithms and sensor models which may introduce varying types and degrees of feature positioning errors.
arcGIS	ArcGIS	ArcGIS software was used to derive features from image source.	
erdas	ERDAS	ERDAS software was used to derive features from image source.	
remoteView	Remote View	Remote View software was used to derive features from image source.	
socetGxp	Socet GXP	Socet GSP software was used to derive features from image source.	
socetSet	Socet Set	Socet Set software was used to derive features from image source.	

Drawn from the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/FeatureExtractionSoftware. If other software packages are used, contact NGA in order that they may be added to the official list.

D.11.2 ImageRectificationMethodCodeList

XML Value	Name	Definition	Description
ImageRectificationMethodCodeList	Image Rectification Method Codelist	A codelist, each domain member of which denotes an image rectification method.	The rectification method that was used to conform an image to align it with a standard coordinate system (for example: a map projection).
imageToMap	Image to Map	The image was adjusted using a rubber-sheet process to align to an existing map or chart feature.	
imageToRectifiedImage	Image to Rectified-image	The image was adjusted using a rubber-sheet process to align to another orthorectified image.	
orthorectification	Orthorectification	The image was rectified to include correcting for terrain displacement.	
sensorModelBased	Sensor Model-based	The image was adjusted by applying sensor model correction default values.	

Drawn from the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/ImageRectificationMethod

D.11.3 ProcessStepType

XML Value	Name	Definition	Description
ProcessStepType	Process Step Type Codelist	A codelist, each domain member of which denotes a process step type.	A process step is an event or transformation in the life of a data resource, including the process(es) used to maintain the data resource.
featureExtraction	Feature Extraction	Features were derived from an image source.	Features are representations of temporally persistent real-world phenomena, including their geometric position and extent.
imageRectification	Image Rectification	An image was conformed to align it with a standard coordinate system (for example: a map projection).	Rectification is correcting for positional displacement with respect to the surface of the earth.
originate	Originate	The content of the resource was created in its initial, original state.	When appropriate, a sequence of more detailed 'creation' sub-steps should be instead specified. The process by which this occurs may be complex and multi-step. The originate step is a simplified synopsis of this complexity as a single generic step.
update	Update	The content of the resource was updated (revised) from an earlier state.	When appropriate, a sequence of more detailed 'update' sub-steps should be instead specified. The process by which this occurs may be complex and multi-step. The update step is a simplified synopsis of this complexity as a single generic step.

Drawn from the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/ProcessStepTypeCode

D.11.4 UniqueResourceIdentStrucText

XML Value	Name	Definition	Structure Specification
UniqueResourceIdentStrucText	Unique Resource Identifier Structured Text	A structured text value specifying a unique resource (for example: dataset or service) identifier.	Structured in accordance with IETF RFC2396 (URI Generic Syntax); the namespace is managed by the NGA National Center for Geospatial Intelligence Standards (NCGIS).

Unique resource identifiers are not chosen from a codelist but must be formatted according to the structure specification.

D.12 NAS – General Datatype Codelists

D.12.1 IdentifierNamespaceCodeList

XML Value	Name	Definition	Description
IdentifierNamespaceCodeList	Identifier Namespace Codelist	A codelist, each domain member of which denotes an identifier namespace.	Each namespace uniquely identifies an information system within which unique identifiers are used to designate individual items.

XML Value	Name	Definition	Description
epsg	European Petroleum Survey Group (EPSG)	The namespace for identifiers and definitions of coordinate reference systems and coordinate transformations that may be global, regional, national or local in application.	The full set of European Petroleum Survey Group (EPSG) definitions is maintained by the International Association of Oil & Gas Producers (IOGP) in an online registry: http://www.epsg-registry.org/.
gencEntity	GENC Entity	The namespace for identifiers of a geopolitical entity (country) within whose geospatial extent this dataset contains (at least partial) information content.	
georef	World Geographic Reference System	The namespace for identifiers of an area-designation method used for US interservice reporting for air defence and strategic air operations.	Assigned identifiers consist of 24 longitudinal zones of 15 degrees width lettered A to Z (omitting I and O) and 12 bands of latitude of 15 degrees lettered A to M (omitting I). The first letter is that of the longitude and the second letter is the latitude band.
gnis	Geographic Names Information System	The namespace established by the United States Board on Geographic Names (US BGN) providing the official repository of domestic geographic names data, the official vehicle for geographic names use by all departments of the US Federal Government, and the source for applying geographic names to US Federal electronic and printed products.	Contains information about physical and cultural geographic features of all types in the United States, associated areas, and Antarctica, current and historical, but not including roads and highways. The database holds the Federally recognized name of each feature and defines the feature location by state, county, US Geological Survey topographic map, and geographic coordinates. Other attributes include names or spellings other than the official name, feature designations, feature classification, historical and descriptive information, and for some categories the geometric boundaries.
gns	GEOnet Names Server	The namespace established by the United States Board on Geographic Names (US BGN) providing the official repository of standard spellings of all foreign geographic names sanctioned by the US BGN.	Contains variant spellings (cross-references), which are useful for finding purposes, as well as non-Roman script spellings of many of these names. All the geographic features in the database contain information about location, administrative division, and quality. The database can be used for a variety of purposes, including establishing official spellings of foreign place names, cartography, GIS, GEOINT, and finding places.
spatiotemporalRefSystem	Spatiotemporal Reference System	The namespace established by the Spatiotemporal Reference Systems Register in the NSG Standards Registry.	Assigned identifiers are an up to thirty-character lower camel-case alphanumeric code; characters are drawn from the range [a...z, A...Z, 0...9].

For NEMIS metadata, these are the only valid values in the NSG Standards Registry codelist:
http://api.nsgreg.nga.mil/codelist/IdentifierNamespace

D.13 NAS – Resource Metadata Codelists

D.13.1 ResourceCategory

XML Value	Name	Definition	Description
ResourceCategory	Resource Category Codelist	A codelist, each domain member of which denotes a resource category.	A taxonomically organized set of categories.
elevation	Elevation	Aspects of GEOINT relating to the three-dimensional arrangement of physical attributes (for example: shape, height, and depth) of the terrestrial surface - whether on land or under water.	

For NEMIS metadata, this is the only valid value in the NSG Standards Registry codelist:
http://api.nsgreg.nga.mil/codelist/ResourceCategoryCode

D.14 IC Information Security Marking Codelist and Structured Text Values

D.14.1 NoticeTypeCodeList

XML Value	Name	Definition	Description
NoticeTypeCodeList	Notice Type Codelist	A codelist, each domain member of which denotes a category of a security-related notice, as as determined by the Intelligence Community (IC) XML Data Encoding Specification (DES) for Information Security Marking (ISM) Metadata (ISM) standard (IC DES.ISM.XML).	Examples may include: the North Atlantic Treaty Organization (NATO), Restricted Data (RD), Formerly Restricted Data (FRD), and Foreign Intelligence Surveillance Act (FISA).
DS	Limited Distribution (LIMDIS) Caveat	A caveat used by the U.S. National Geospatial-Intelligence Agency (NGA) to identify a select group of sensitive, unclassified imagery or geospatial information and data created or distributed by NGA or information, data, and products derived from such information.	DoDI 5030.59 (Reference (x)) contains details of policies and procedures regarding use of the LIMDIS caveat. Reference: DoD Manual 5200.01, Volume 4, February 24, 2012.

For the full list of notice types, consult the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/NoticeTypeCode

D.14.2 ResClassificationStrucText

XML Value	Name	Definition	Structure Specification
ResClassificationStrucText	Resource Classification Codelist	A structured text consisting of a single value that is drawn from a codelist, each domain member of which denotes a security classification that is applicable to a resource.	A character string consisting of a one or two-character alphabetic code drawn from a codelist domain specified by the (US) Intelligence Community implementation profile for information security markings.
S	S	SECRET	
TS	TS	TOP SECRET	
U	U	UNCLASSIFIED	

Drawn from the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/ResClassification

D.14.3 ResDeclassDateStrucText

XML Value	Name	Definition	Structure Specification
ResDeclassDateStrucText	Resource Declassification Date Structured Text	A structured text value specifying a resource declassification date.	Formatted in accordance with ISO 8601:2000, a calendar date representation, as a single data element comprising ten characters, where [YYYY] represents a calendar year, [MM] the ordinal number of a calendar month within the calendar year, and [DD] the ordinal number of a day within the calendar month, where the three components are separated by the hyphen '-' character (for example: '1985-04-12').

Declassification dates are not chosen from a codelist but must be formatted according to the structure specification.

D.14.4 ResDissemControlsStrucText

XML Value	Name	Definition	Structure Specification
ResDissemControlsStrucText	Resource Dissemination Controls Structured Text	A structured text consisting of a sequence of values that are individually drawn from a codelist, each domain member of which denotes a dissemination control that is applicable to a resource.	A character string consisting of an ordered list of space-separated codelist values. The codelist domain is specified by the (US) Intelligence Community implementation profile for information security markings.
FOUO	FOUO	FOR OFFICIAL USE ONLY	
NF	NF	NOT RELEASABLE TO FOREIGN NATIONALS	
REL	REL	AUTHORIZED FOR RELEASE TO	
RS	RS	RISK SENSITIVE	

For the full list of resource dissemination controls, consult the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/ResDissemControls

D.14.5 ResNonIntelComMarkingsStrucText

XML Value	Name	Definition	Structure Specification
ResNonIntelComMarkingsStrucText	Resource Non-Intelligence Community Markings Structured Text	A structured text consisting of a sequence of values that are individually either drawn from a (US) Intelligence Community codelist or are a North Atlantic Treaty Organization Special Word, where each member of the sequence denotes a non-intelligence community marking that is applicable to a resource.	A character string consisting of an ordered list of space-separated values each of which is either determined by a codelist or restricted to the following pattern: "ACCM-[A-Z0-9\-_]{1,61}". The codelist domain is specified by the (US) Intelligence Community implementation profile for information security markings. In the pattern an underscore ("_") is used to indicate where the North Atlantic Treaty Organization Special Word contains a space.
DS	DS	LIMITED DISTRIBUTION	
SBU	SBU	SENSITIVE BUT UNCLASSIFIED	

For the full list of non-IC community markings, consult the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/ResNonIntelComMarkings

D.14.6 ResOwnerProducerStrucText

XML Value	Name	Definition	Structure Specification
ResOwnerProducerStrucText	Resource Owner-Producer Structured Text	A structured text consisting of a sequence of values that are individually either drawn from a (US) Intelligence Community codelist or are a North Atlantic Treaty Organization Special Word, where each member of the sequence denotes an owner-producer that is applicable to a resource.	A character string consisting of an ordered list of space-separated values each of which is either determined by a codelist or restricted to the following pattern: "NATO/[a-zA-Z\-_]". The codelist domain is specified by the (US) Intelligence Community implementation profile for information security markings. In the pattern an underscore ("_") is used to indicate where the North Atlantic Treaty Organization Special Word contains a space.
USA	USA	United States of America	

For data with foreign classifications, consult the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/ResOwnerProducer

D.14.7 ResReleasableToStrucText

XML Value	Name	Definition	Structure Specification
ResReleasableToStrucText	Resource Releasable To Structured Text	A structured text consisting of a sequence of values that are individually either drawn from a (US) Intelligence Community codelist or are a North Atlantic Treaty Organization Special Word, where each member of the sequence denotes a releasability-to that is applicable to a resource.	A character string consisting of an ordered list of space-separated values each of which is either determined by a codelist or restricted to the following pattern: "NATO/[a-zA-Z\-_]". The codelist domain is specified by the (US) Intelligence Community implementation profile for information security markings. In the pattern an underscore ("_") is used to indicate where the North Atlantic Treaty Organization Special Word contains a space.
AUS	AUS	Commonwealth of Australia	
CAN	CAN	Canada	
FVEY	FVEY	FIVE EYES	
GBR	GBR	United Kingdom of Great Britain and Northern Ireland	
NZL	NZL	New Zealand	

For the full list of releasable-to values (country and organization codes), consult the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/ResReleasableTo

D.14.8 ResSciControlsStrucText

XML Value	Name	Definition	Structure Specification
ResSciControlsStrucText	Resource SCI Controls Structured Text	A structured text consisting of a sequence of values that are individually drawn from a codelist, each domain member of which denotes an SCI control that is applicable to a resource.	A character string consisting of an ordered list of space-separated codelist values. The codelist domain is specified by the (US) Intelligence Community implementation profile for information security markings.
RSV	RSV	RESERVE	
SI	SI	SPECIAL INTELLIGENCE	
SI-G	SI-G	SI-GAMMA	
TK	TK	TALENT KEYHOLE	

For the full list of SCI controls, consult the NSG Standards Registry codelist: http://api.nsgreg.nga.mil/codelist/ResSciControls

Annex E NEMIS Elevation Quality Measures

E.1 Introduction

ISO 19157 Geographic Information – Data quality establishes principles for describing the quality of geographic data, including both the structure for a register of data quality measures, and definitions for a set of measures for use in evaluating and reporting geographic data quality.

NGA has established such a quality measures register: https://nsgreg.nga.mil/ir/registers.jsp?register=QM

The NEMIS metadata model employs a subset of registered quality measures to characterize gridded and point cloud data. That subset is specified in Annex E.2.

Registered Quality Measures are identified by URIs composed from the **~/qual-measure/** base URL plus an XML alphacode identifier shown in Table E-1. For example, in the case of absolute Linear Error at the 90% probability level ($LE90_{ABS}$), this identification is by the URI:

http://api.nsgreg.nga.mil/qual-measure/LinearMapAccuracy90

Each URI has a corresponding measure-specific accessible information resource whose content may be directly accessed by Internet-connected applications via a REpresentational State Transfer (REST) API.

E.2 NEMIS Quality Measures

The quality attributes that can be used to quantify the accuracy of elevation data in NEMIS metadata are shown below. Each is based on a Quality Measure defined by the NSG in the Information Resource (IR) Registry. The Quality Measure definitions are different from, but equivalent to, those in NGA.SIG.0026.02_1.0_ACCGLOS. In addition to the four standard accuracy measurements shown in **Table 4-3**, four additional measurements ($CE95_{ABS}$, $LE95_{ABS}$, SE90, and RMSE) are provided for datasets possessing those values. Both $CE90_{ABS}$ and $LE90_{ABS}$ measurements are required for all datasets, and $LE90_{REL}$ is strongly recommended whenever its estimation is possible. If only SE90 is available, its value should also be substituted for both $CE90_{ABS}$ and $LE90_{ABS}$.

Table E-1. NEMIS Quality Measures

Term	Description	`XML Value` / NSG Name	NSG Definition	NEMIS Quality Class[1]
$CE90_{ABS}$	Absolute horizontal accuracy at the 90% probability level	**`CircularMapAccuracyStd`** Circular Map Accuracy Standard	The radius describing a circle, in which the true point location lies with the probability of 90 percent.	DQ_AbsoluteExternalPositionalAccuracy
$CE95_{ABS}$	Absolute horizontal accuracy at the 95% probability level	**`CircularError95`** Circular Error at 95% Significance Level	The radius describing a circle, in which the true point location lies with the probability of 95 percent.	DQ_AbsoluteExternalPositionalAccuracy
$LE90_{ABS}$	Absolute vertical accuracy at the 90% probability level	**`LinearMapAccuracy90`** Linear Map Accuracy at 90% Significance Level	The half-length of the interval defined by an upper and a lower limit, in which the true value lies with probability 90 percent.	DQ_AbsoluteExternalPositionalAccuracy
$LE95_{ABS}$	Absolute vertical accuracy at the 95% probability level	**`LinearMapAccuracy95`** Linear Map Accuracy at 95% Significance Level	The half-length of the interval defined by an upper and a lower limit, in which the true value lies with probability 95 percent.	DQ_AbsoluteExternalPositionalAccuracy
$CE90_{REL}$	Relative horizontal accuracy at the 90% probability level	**`RelativeHorizontalError`** Relative Horizontal Error	An evaluation of the random errors in the horizontal position of one feature to another in the same dataset or on the same map/chart.	DQ_RelativeInternalPositionalAccuracy
$LE90_{REL}$	Relative vertical accuracy at the 90% probability level	**`RelativeVerticalError`** Relative Vertical Error	An evaluation of the random errors of one relief feature to another in the same dataset or on the same map/chart. It is a function of the random errors in the two elevations with respect to a common vertical datum.	DQ_RelativeInternalPositionalAccuracy
SE90	Absolute spherical accuracy at the 90% probability level	**`SphericalSpatialAccuracy90`** Spherical Spatial Accuracy at 90% Significance Level	The radius of a spherical volume that is specified with respect to a three-dimensional spatial reference frame and within which the true positional value lies with probability 90 percent.	DQ_AbsoluteExternalPositionalAccuracy
RMSE	Root mean square error	**`RootMeanSquareError`** Root Mean Square Error	A standard deviation, where the true value is not estimated from the observations but known a priori.	DQ_AbsoluteExternalPositionalAccuracy

[1] See Annex C.21 for NEMIS quality class definitions. The Data Quality UML diagram in Figure B-9 shows how each quality measure is expressed as a Record in the metadata.

Annex F NMF Minimum Mandatory Metadata

F.1 Introduction

The NSG Metadata Foundation (NGA.STND.0012_3.0_NMF), Table 1, specifies a set of minimum mandatory metadata elements for data resource identification and access. The NEMIS metadata model specifies a superset of those minimum metadata requirements. Annex F.2 documents the manner in which those requirements are met.

F.2 Minimum Mandatory Metadata

Table F-1 identifies the NMF minimum mandatory metadata elements for data resource identification and access and their relative location within the NEMIS metadata model with respect to the root class MD_Metadata. Table references in the Domain Guidance column are to those in NGA.STND.0012_3.0_NMF.

Table F-1. NEMIS paths for NMF minimum mandatory metadata

Core Metadata Concept	Multi-plicity	NEMIS Path	NMF Definition	Domain Guidance
Metadata Point of Contact	1..*	MD_Metadata/metaContact	The party or parties acting in a role of responsibility for a set of resource metadata. The first instance of this element is to have the role of “creator”.	Resource Metadata (Table 7) Metadata Contact – Populate using the Responsibility datatype (Table 46) with RoleCode (Table 3) of ‘pointOfContact’ and identifying the individual or organization responsible for the metadata record.
Metadata Date	1..*	MD_Metadata/dateInfo/CI_Date/ date	The date(s), and optionally time(s), of an event involving a set of resource metadata. The first instance of this element is to have the role of “creation”.	Resource Metadata (Table 7) Resource Metadata Date – Populate using Date datatype (Table 50) with the DateTypeCode (Table 3) such as ‘creation’, ‘publication’, or ‘revision’ for when the metadata record was created, published, or revised.
Metadata Standard Title	1	MD_Metadata/metadataStandard/ CI_Citation/title	The name of the metadata standard which determines the structure and content of this set of resource metadata.	Resource Metadata (Table 7) Metadata Standard Citation – Populate using Citation datatype (Table 45) identifying the Cited Resource Title of the standard used for the metadata record.
Metadata Standard Edition	1	MD_Metadata/metadataStandard/ CI_Citation/edition	The version of the metadata standard which determines the structure and content of this set of resource metadata.	Resource Metadata (Table 7) Metadata Standard Citation – Populate using Resource Identifier (Table 45) identifying the code for the edition of the standard used for the metadata record.

Core Metadata Concept	Multi-plicity	NEMIS Path	NMF Definition	Domain Guidance
Metadata Scope Code	1	MD_Metadata/metadataScope/ MD_MetadataScope/resourceScope	A brief indicator of the type of resource for which metadata information is reported.	Metadata Scope (Table 8) Resource Scope – Populate using ScopeCode codelist (Table 3) to identify the type of resource the metadata applies to such as 'dataset', 'attribute', or 'feature'.
Metadata Scope Name	1	MD_Metadata/metadataScope/ MD_MetadataScope/ resourceScopeName	A word or phrase that describes the type of resource for which information is reported.	Metadata Scope (Table 8) Resource Scope – Populate using Resource Scope Name identifying type of resource if Resource Scope is not 'dataset'.
Metadata Classification	1	MD_Metadata/metadataConstraints/ ResourceConstraints/securityMarking/ resClassification	The classification level of the metadata, in accordance with the Intelligence Community (IC) Security Markings Manual.	Security Attributes Group (Table 33) Resource Classification – Populate with ResClassificationStrucText datatype (Table 33).
Metadata Classification System	1	MD_Metadata/metadataConstraints/ ResourceConstraints/securityMarkings/ resOwnerProducer	The classification system of the metadata, in accordance with the Intelligence Community (IC) Security Markings Manual.	Security Attributes Group (Table 33) Resource Owner-Producer – Populate with ResOwnerProducerStrucText datatype (Table 33).
Resource Title	1	MD_Metadata/identificationInfo/ MD_Identification/citation/CI_Citation/ title	The name by which a cited resource is known.	Resource Identification (Table 9) Resource Citation – Populate with Cited Resource Title (Table 45).
Resource Abstract	1	MD_Metadata/identificationInfo/ MD_Identification/abstract	A brief statement or narrative summary of the resource.	Resource Identification (Table 9) Resource Abstract – Populate with free text providing a short description of the resource.
Resource Point of Contact	1..*	MD_Metadata/identificationInfo/ MD_Identification/pointOfContact	The party(ies) acting in a role of responsibility for the resource. The first instance of this element is to have the role of "originator".	Resource Identification (Table 9) Resource Point of Contact – Populate using the Responsibility datatype (Table 46) with RoleCode (Table 3) of 'pointOfContact' and identifying the individual or organization responsible for the metadata record.
Resource Date	1	MD_Metadata/identificationInfo/ MD_Identification/citation/CI_Citation/ date	A reference date for a cited resource. The first instance of this element is to have the role of "creation".	Resource Identification (Table 9) Resource Citation – Populate using Cited Resource Date (Table 45) with the date and DateType (Table 3) such as 'creation', 'publication', or 'revision' for when the metadata record was created, published, or revised.
Resource Identifier	1	MD_Metadata/identificationInfo/ MD_Identification/citation/CI_Citation/ citIdentifier	A value uniquely identifying the resource within a namespace.	Resource Identification (Table 9) Resource Citation – Populate using Cited Resource Identifier (Table 45) identifying the code for the unique resource identifier.
Resource Geographic Location	1..*	MD_Metadata/identificationInfo/ MD_Identification/resourceExtent	The spatial extent of the resource. The spatial extent is a geographic identifier (for example: a country name), a bounding box (for example: the bounding latitudes and longitudes), or a bounding object (for example: a set of coordinate points).	Resource Identification (Table 9) Resource Extent – Populate using Resource Extent (Table 38) to specify a Geographic Bounding Box, Geographic Description, or Geographic Bounding Object.

Core Metadata Concept	Multi-plicity	NEMIS Path	NMF Definition	Domain Guidance
Resource Language	1	MD_Metadata/identificationInfo/ MD_Identification/defaultLocale/ PT_Locale/language	Designation of the locale language.	Data Identification (Table 10) Text Locale – Populate using Locale Language (Table 55) LanguageCode codelist (Table 3) to identify language of resource.
Resource Character Set	1	MD_Metadata/identificationInfo/ MD_Identification/defaultLocale/ PT_Locale/characterEncoding	Designation of the character set to be used to encode the textual value of the locale.	Data Identification (Table 10) Text Locale – Populate using Locale Character Encoding (Table 55) IANA Charset codelist (Table 3) to identify character set used in resource.
Resource Topic Category Code	1	MD_Metadata/identificationInfo/ MD_Identification/topicCategory	A theme or topic keyword that represents a subject of the resource.	Resource Identification (Table 9) Topic Category – Populate using MD_TopicCategoryCode enumeration (Table 4).
Resource Keywords	1..*	MD_Metadata/identificationInfo/ MD_Identification/descriptiveKeywords	Information about keywords describing this resource.	Keywords (Table 12) Keywords – Populate with Keyword to identify content of the resource.
Resource Classification	1	MD_Metadata/identificationInfo/ DataIentification/resourceConstraints/ ResourceConstraints/securityMarkings/ SecurityAttributesGroupType/ resClassification	The classification level of the resource, in accordance with the Intelligence Community (IC) Security Markings Manual.	Security Attributes Group (Table 33) Resource Classification - Populate with ResClassificationStrucText datatype (Table 33).
Resource Classification System	1	MD_Metadata/identificationInfo/ DataIentification/resourceConstraints/ ResourceConstraints/securityMarkings/ SecurityAttributesGroupType/ resOwnerProducer	The classification system of the resource, in accordance with the Intelligence Community (IC) Security Markings Manual.	Security Attributes Group (Table 33) Resource Owner-Producer – Populate with ResOwnerProducerStrucText datatype (Table 33).
Resource Category	1	MD_Metadata/identificationInfo/ MD_Identification/resourceCategory	The particular category of a data resource within a defined taxonomy. Resources within a category have similar information content and have been produced by similar processing methods. The default is a resource category type of "other".	NMF Data Identification (Table 11) Data Identification – Populate with Resource Category using code from ResourceCategoryCode codeList (Table 3).
Metadata Language	1	MD_Metadata/defaultLocale/ PT_Locale/language	Designation of the locale language.	Obligation: Required when not defined by encoding. Data Identification (Table 10) Text Locale – Populate using Locale Language (Table 55) LanguageCode codelist (Table 3) to identify language of resource.
Metadata Character Set	1	MD_Metadata/defaultLocale/ PT_Locale/characterEncoding	Designation of the character set to be used to encode the textual value of the locale.	Obligation: Required when not defined by encoding. Data Identification (Table 10) Text Locale – Populate using Locale Character Encoding (Table 55) IANA Charset codelist (Table 3) to identify character set used in resource.

Core Metadata Concept	Multi-plicity	NEMIS Path	NMF Definition	Domain Guidance
Parent Metadata Citation	0..1	MD_Metadata/parentMetadata	A standardized reference to a set of metadata that is in a parent relationship to this set of resource metadata.	Obligation: Required if there is an upper scope Level. Resource Identification (Table 9) Parent Metadata Citation – Populate using Citation datatype (Table 45) identifying the identifier of parent metadata.
Resource Temporal Extent	1	MD_Metadata/identificationInfo/ MD_Identification/resourceExtent/ EX_Extent/temporalElement/ EX_TemporalExtent/temporalExtent	The time period covered by the resource	Obligation: Required when Resource Extent Description, or Geographic Extent, or Vertical Extent not documented. Temporal Extent (Table 43) Temporal Extent – Populate using Temporal Geometric Primitive (Table 60), such as Temporal Period or Temporal Instance.
Resource Coordinate Reference System	1	MD_Metadata/referenceSystemInfo/ MD_ReferenceSystem/ referenceSystemIdentifier	Information about a spatial or temporal reference system used by representations in the resource	Obligation: Required if the resource includes coordinates. Reference System Information (Table 37) Reference System Identifier – Populate with Identifier (Table 54) Code identifying the reference system used in the resource.

Annex G NEMIS Metadata Exchange

G.1 Introduction

Successful employment of the NEMIS XSD-based metadata schema specification requires knowledge of the conformance testing requirements and the structure, content, and use of the XML Schema and Schematron components of the NEMIS encoding.

Conformance with the NEMIS XSD-based exchange model shall be determined through the use of a validating XML processor and a Schematron validator. In general, these tests are used to determine if an XML instance document is both well-formed (meets syntactic requirements) and valid (meets logical requirements) with respect to the NEMIS, and in the case of a NEMIS-conformant application whether it correctly writes and/or reads NEMIS-conformant instance documents. Annexes G.2 and G.3 specify these requirements.

Annex G.4 describes the structure and content of the NEMIS XML Schema and Schematron files in relationship to both XML instance document generation and validation.

Annex G.5 presents encoding guidelines for use in preparing valid NEMIS XML instance documents.

G.2 XML Conformance

G.2.1 Validating XML Processor

XML Schema 1.0 (Second Edition) describes a class of data objects called “XML instance documents” and partially describes the behavior of computer programs which process them.

XML instance documents are made up of storage units called “entities,” which contain either parsed or unparsed data. Parsed data is made up of characters, some of which form character data, and some of which form markup. Markup encodes a description of the storage layout and logical structure of an XML instance document. XML provides a mechanism to impose constraints on that storage layout and logical structure.

An XML schema is used to describe the structure of an XML instance document by specifying the valid elements that can occur in that document, prescribing the order in which they can occur, and expressing constraints on certain aspects of these elements. These constraints may be as simple as “The Name in an element's end-tag must match the element type in the start-tag.” and “An element type must not be declared more than once.”; however, many are more complex.

An XML schema is intended as a machine-readable mechanism to describe what constitutes a valid XML instance document according to a particular XML vocabulary. An XML schema defines what constraints an XML instance document producer commits to meeting and what expectations an XML instance document consumer must meet in order to ensure that the transmission of that document from producer to consumer results in a complete and faithful data exchange. Typically, the consumer ensures that the XML instance document being received from the producer conforms to that producer commitment by validating the received document against its specified XML Schema document (XSD).

Usually, a general-purpose XML processor is used to read XML instance documents, providing access to their content and structure; this is typically accomplished on behalf of a specialized application. XML Schema 1.0 (Second Edition) describes the required behavior of that XML processor in terms of how it must read XML data and the information that it must provide to that specialized application. Usually a “validating” XML processor is employed, which is required to examine every component of the XML instance document and report all well-formedness and validity violations.

G.2.2 Schematron Validator

ISO/IEC 19757-3:2016 defines the Schematron Document Schema Definition Language (DSDL) that may be used to specify one or more validation processes to be performed against XML instance documents. Schematron is a rule-based validation language for making assertions about the presence or absence of patterns in XML trees. It is a simple and powerful structural schema language expressed in XML using a small number of elements and XML Path Language (XPath), a query language for selecting nodes from an XML document. It may be employed as an adjunct to the structural validation capabilities of XML Schema Definition (XSD): testing for co-occurrence constraints, non-regular constraints, and interdocument constraints.

Schematron is a language system for specifying and declaring assertions about arbitrary patterns in XML documents, based on the presence or absence, names and values of elements and attributes along paths. It uses the languages of XPath Version 1.0 and Extensible Stylesheet Language Transformations (XSLT) Version 1.0 or Version 2.0. The NEMIS follows the (U.S.) Intelligence Community (IC) practice of using XSLT Version 2.0 and follows the same patterns used by the IC for Schematron assertions.

Considered as a document type, a Schematron schema (.sch file) contains natural-language assertions concerning a set of XML documents, marked up with various elements and attributes for testing these natural-language assertions, and for simplifying and grouping assertions.

Considered theoretically, a Schematron schema reduces to a non-chaining rule system whose terms are Boolean functions invoking an external query language on the instance and other visible (*e.g.*, accessible external resource) XML documents, with syntactic features to reduce specification size and to allow efficient implementation.

Considered analytically, Schematron has two characteristic high-level abstractions: the pattern and the phase. These allow the representation of non-regular, non-sequential constraints that *ISO/IEC 19757-2:2008 Document Schema Definition Languages (DSDL – Part 2: Regular grammar-based validation – RELAX NG)* cannot specify, and various dynamic or contingent constraints.

A general Schematron validator is a function returning an indication that an XML document is “valid,” “invalid” or “error.” The function notionally performs two steps: transforming the specified Schematron schema into a minimal syntax, and then testing the XML document against the minimal syntax. It is common to implement Schematron validators directly using XSLT.

ISO/IEC 19757-3:2016, Annex H (Query Language Binding for XSLT2) specifies that a Schematron schema with a **`queryBinding`** attribute with the value **`xslt2`**, in any mix of upper- and lower-case letters, shall use the following binding:

- The query language used is the extended version of XPath2 specified in XSLT2 with backwards compatability mode as false. Consequently, the data model used is the XPath Data Model (XDM) contructed from an infoset or a Post Schema Validation Infoset (PSVI). All namespaces, prefixes, functions and operators defined by XPath2 Functions shall be available. An implementation may allow user-written functions and extensions, in the appropriate namespace.

- The rule context is interpreted according to the Production 1 of XSLT2. The rule context may be root nodes, elements, attributes, comments and processing instructions, including sequences of

these. An implementation may allow the rule context to be text nodes at user option; however, implementations may reject or fail to implement schemas which specify text nodes.

- The **`assertion`** test is interpreted according to Production 1 of XPath2, using **`fn:boolean()`** on the result of evaluating the expression and to find the effective boolean value.
- The **`name`** query is interpreted according to Production 1 of XPath2, using **`fn:node-name()`** on the result of evaluating the expression which should be an element or attribute node and returning a string value.
- The **`value-of`** query is interpreted according to Production 1 of XPath2, using **`fn:string()`** on the result of evaluating the expression and returning a string value.
- The **`let`** value is interpreted according to Production 1 of XPath2.
- The **`documents`** attribute of the element shall be interpreted according to the Production 1 of XSLT2, as returning a sequence of strings that are evaluated using the **`document()`** function.
- The notation for signifying the use of parameter of an abstract pattern is to prefix the name token with the character. This is a character not found as a delimiter in URLs or XPaths. The character not followed by the name of an in-scope parameter shall not be treated as a parameter name delimiter. Such a character may subsequently be used as a delimiter for a variable name or as a literal character.
- A Schematron **`let`** expression is treated as an XSLT2 variable. The XSLT2 **`$`** delimiter signifies the use of a variable in a context expression, assertion test, name query, value-of query or let expression. The character not followed by the name of an in-scope variable shall be treated as a literal character.
- All namespaces and prefixes defined by XSLT2 for modules are reserved with their XSLT2 usage. All functions defined by these modules shall be available in addition to the functions defined by XPath2 Functions.
    - The XSLT2 **`key`** element may be used, in the XSLT2 namespace, before the pattern elements.
    - The XSLT2 **`function`** element may be used, in the XSLT2 namespace, before the pattern elements.
    - The XSLT2 **`copy-of`** element may be used, in the XSLT2 namespace and without child nodes, inside the property element.
    - The attributes **`id`**, **`name`** and **`prefix`** should follow the rules for non-colonized names for the version of XML used by the document.
    - The **`fn:error()`** function or other dynamic errors should not be used to provide assertion text or to substitute for assertions and diagnostics.

While the *ISO/IEC 19757-3:2016 Default Query Language Binding* uses XSLT 1.0, XSLT 2.0 Query Language Bindings may be employed as specified in Annex H of that standard.

Schematron files included in the NEMIS are used to define applicable constraint rules; they are not a required implementation. Implementers can use any tools at their disposal as long as the data complies with the rules expressed. To facilitate testing and understanding of the rules they may be executed in, *e.g.*, the oXygen® XML Editor, XML ValidatorBuddy®, or the XSLT 2.0 implementation of ISO Schematron published on GitHub (https://github.com/schxslt/schxslt). For additional information, see: http://schematron.com/.

G.3 NEMIS Conformance Testing

G.3.1 Metadata Instance Document

Conformance of an XML instance document to the NEMIS requires that the following set of conditions be met. In general, these tests will be applied in the sequence specified.

1. The XML instance document, when evaluated against *nemis.xsd* and the specified NSG Registry-based imported schema resources using a validating XML processor, shall be determined to be **well-formed** in accordance with the XML Schema 1.0 (Second Edition) standard.

2. The XML instance document, when evaluated against *nemis.xsd* and the specified NSG Registry-based imported schema resources using a validating XML processor, shall be determined to be **valid** in accordance with the XML Schema 1.0 (Second Edition) standard. This test ensures that the document meets the conformance requirements of ISO/TS 19115-3, and other XML schemas which the NEMIS imports, including the NAS.

3. The XML instance document, when evaluated against *nemis.sch* using a Schematron validator conforming to the requirements of ISO/IEC 19757-3:2016, shall be determined to be **valid**. This test ensures that the document satisfies all constraints specified by ISO/TS 19115-3, other XML schemas which the NEMIS imports, and the NEMIS itself, that cannot be enforced using XSD.

G.3.2 Metadata Document Generation

A sampling approach is often used to demonstrate confidence that all NEMIS instance documents generated by the system under test are (and will be) NEMIS-conforming. The implementing system has operational, functional, and design-specific requirements for populating the mandatory, conditional and optional elements of metadata. There may be differing requirements specific to each variety of data or service to be described by the system-generated metadata. Based on analysis of the system's metadata generation requirements and design, test cases are formulated to exercise the variety of combinations and permutations of the required metadata characteristics. Metadata instance documents generated by the system for each test case shall satisfy the set of conditions specified in Annex G.3.1.

G.3.3 Metadata Document Consumption

The system under test shall demonstrate that it successfully extracts all component values of any XML instance document that has been demonstrated to be NEMIS-conformant, as determined by the set of conditions specified in Annex G.3.1.

A sampling approach is often used to demonstrate confidence that the system under test can successfully and meaningfully consume (extract component values from) any NEMIS-conforming instance document. A set of NEMIS-conforming instance documents that collectively exercise the extent and variety of

mandatory, conditional, and optional elements of metadata permitted by the NEMIS specification is presented for consumption by the system under test. The capability to meaningfully extract all component values is evaluated within the context of the operational, functional, and performance requirements of the system under test.

G.4 NEMIS Structure and Content

G.4.1 XML Namespaces

The NEMIS XSD-based schema is specified by an XSD file (*nemis.xsd*) plus a Schematron file (*nemis.sch*).

As a subset of the XSD-based encoding of the NAS, the NEMIS is specified in terms of NAS-conforming XSD elements, types, and assertiona. These are referenced as follows:

- XML Namespace Abbreviation: nas
- XML Namespace URI: http://api.nsgreg.nga.mil/schema/nas/base19Jun

The NAS XSD-based encoding, in turn, references a set of XML namespaces determined by external authorities. The additional XML namespaces used by the NEMIS are specified in Table G-1.

Table G-1. XML namespaces employed by the NEMIS

XML Namespace Abbreviation	XML Namespace URI	Standard	UML Package Name(s)
cit	http://standards.iso.org/iso/19115/-3/cit/2.0	ISO 19115-3:2016	Citation
gco	http://standards.iso.org/iso/19115/-3/gco/1.0	ISO 19115-3:2016	Basic Types
gex	http://standards.iso.org/iso/19115/-3/gex/1.0	ISO 19115-3:2016	Extent
lan	http://standards.iso.org/iso/19115/-3/lan/1.0	ISO 19115-3:2016	Language-Characterset Localization
mcc	http://standards.iso.org/iso/19115/-3/mcc/1.0	ISO 19115-3:2016	Commonly Used Classes
mco	http://standards.iso.org/iso/19115/-3/mco/1.0	ISO 19115-3:2016	Constraints
mdb	http://standards.iso.org/iso/19115/-3/mdb/2.0	ISO 19115-3:2016	Metadata Entity Set
mmi	http://standards.iso.org/iso/19115/-3/mmi/1.0	ISO 19115-3:2016	Maintenance
mrd	http://standards.iso.org/iso/19115/-3/mrd/1.0	ISO 19115-3:2016	Distribution
mri	http://standards.iso.org/iso/19115/-3/mri/1.0	ISO 19115-3:2016	Identification
mrl	http://standards.iso.org/iso/19115/-3/mrl/2.0	ISO 19115-3:2016	Lineage & Lineage Extension
mrs	http://standards.iso.org/iso/19115/-3/mrs/1.0	ISO 19115-3:2016	Reference System
msr	http://standards.iso.org/iso/19115/-3/msr/2.0	ISO 19115-3:2016	Spatial Representation
mdq	http://standards.iso.org/iso/19157/-2/mdq/1.0	ISO 19157-2:2016	Data Quality & Data Quality - Result
gml	http://www.opengis.net/gml/3.2	OGC 07-036r1	Geometry & Temporal Objects
swe	http://www.opengis.net/swe/2.0	OGC 08-094r1	SWE Common
xlink	http://www.w3.org/1999/xlink	W3C XLink V1.1	
ism	urn:us:gov:ic:ism	ISM.XML.V13	IC - Information Security Marking
ntk	urn:us:gov:ic:ntk	NTK.XML.V10	IC - Need-to-Know Metadata
rr	urn:us:gov:ic:revrecall	RevRecall.XML.V1	IC - Revision Recall

While in most cases the full specification of the content of the XML namespace is accessible at the specified URI, in the cases where a URN is employed NGA has published a key subset of the content of a specific version of that namespace. In addition, in order to ensure a coherent set of XML namespace

content for users of XSD-based encodings of the NAS, NGA has mirrored key content for all externally-defined XML namespaces. Table G-2 specifies the set of imports used by the NEMIS.

Table G-2. NEMIS namespace imports

xmlns	XML Namespace declaration	XML Namespace import
cit	http://standards.iso.org/iso/19115/-3/cit/2.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/cit/2.0
gco	http://standards.iso.org/iso/19115/-3/gco/1.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/gco/1.0
gex	http://standards.iso.org/iso/19115/-3/gex/1.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/gex/1.0
lan	http://standards.iso.org/iso/19115/-3/lan/1.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/lan/1.0
mcc	http://standards.iso.org/iso/19115/-3/mcc/1.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/mcc/1.0
mco	http://standards.iso.org/iso/19115/-3/mco/1.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/mco/1.0
mdb	http://standards.iso.org/iso/19115/-3/mdb/2.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/mdb/2.0
mmi	http://standards.iso.org/iso/19115/-3/mmi/1.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/mmi/1.0
mrd	http://standards.iso.org/iso/19115/-3/mrd/1.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/mrd/1.0
mri	http://standards.iso.org/iso/19115/-3/mri/1.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/mri/1.0
mrl	http://standards.iso.org/iso/19115/-3/mrl/2.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/mrl/2.0
mrs	http://standards.iso.org/iso/19115/-3/mrs/1.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/mrs/1.0
msr	http://standards.iso.org/iso/19115/-3/msr/2.0	http://api.nsgreg.nga.mil/schema/iso/19115/-3/msr/2.0
mdq	http://standards.iso.org/iso/19157/-2/mdq/1.0	http://api.nsgreg.nga.mil/schema/iso/19157/-2/mdq/1.0
gml	http://www.opengis.net/gml/3.2	http://api.nsgreg.nga.mil/schema/gml/3.2
swe	http://www.opengis.net/swe/2.0	http://api.nsgreg.nga.mil/schema/swe/2.0
xlink	http://www.w3.org/1999/xlink	http://api.nsgreg.nga.mil/schema/w3c/xlink/1999
ism	urn:us:gov:ic:ism	http://api.nsgreg.nga.mil/schema/ic/ism/V13
ntk	urn:us:gov:ic:ntk	http://api.nsgreg.nga.mil/schema/ic/ntk/V10
rr	urn:us:gov:ic:revrecall	http://api.nsgreg.nga.mil/schema/ic/RevRecall/V1

These resources are organized into a hierarchy in accordance with the requirements of the organization that governs them (*e.g.*, ISO or OGC), the specific standard that they support (*e.g.*, ISO 19115-1), the XML namespace that they define (*e.g.*, “cit”), and the version/edition of that XML namespace (*e.g.*, “2.0” or “V13”).

G.4.2 XSD Profile Restrictions

Many XML development tools can use XSD files to automate the development of interfaces and applications in a web services environment. In such an environment, it may be advantageous to limit XSD schema definitions to just those that are mandatory or recommended portions of a larger reference schema (or schema set). Doing so eliminates the overhead of managing and processing aspects of XML namespace content that is not relevant.

The resulting XSD is also easier for system developers to directly inspect and comprehend.

The NEMIS XSD-based schema consists of a subset of the content of the “nas” and related external XML namespaces that:

1. Removes XML elements, attributes, and types that were optional (*e.g.*, the XML element **`minOccurs`** facet value is zero) but are specifically **excluded** by the NEMIS.

2. Restricts the cardinality (multiplicity) of XML elements that are included the NEMIS. For example, the usage of metadata elements may be altered to make elements **mandatory** that are optional

in the NAS or external schemas. Restrictions on cardinality are accomplished by changing the **`minOccurs`** or **`maxOccurs`** values in the applicable XSD.

The result of this transformation is a set of local-use resources (XSD files) that have been tailored for use in NEMIS instance data development and validation. The resulting parsimonious set of files are a functional subset of those published by the respective authorities and mirrored by NGA; in some cases a given XML namespace may (efficiently) have but a single XSD file whereas the authoritative source or mirror may employ a set of XSD files to specify the full content of that XML namespace.

A complete set of these "trimmed" resources is published as a self-contained archive that may be used without dependency on access to, and the availability of, corresponding network-based resources. The resulting NEMIS technical artifact is published in the NSG Standards Registry. In that technical artifact all XML namespaces are resolved to local filesystem references to XSD files containing tailored XML Schemas, thus resulting in a "stand alone" development and validation environment for the NEMIS.

G.4.3 Schematron Constraints

ISO/IEC 19757-3:2006 defines the Schematron Document Schema Definition Language (DSDL) that may be used to specify one or more validation processes to be performed against XML instance documents (see Annex G.2.2).

The NEMIS XSD-based schema is accompanied by a Schematron ruleset ("nemis.sch") to be used to test comformance with the NEMIS logical mertadata model (Annex B), data dictionary (Annex C), and restrictions on code lists and structured text values (Annex D). This set of assertions tests for conformance with:

- Conditional restrictions on cardinalities, equivalent to either increasing the value of the **`minOccurs`** facet from zero to one or decreasing the value of the **`maxOccurs`** facet from unbounded to a smaller fixed number, such as 1.
- Restrictions on NAS value domains as specified in Annex D – *e.g.*, requiring that cit:CI_RoleCode values be selected from those in Annex D.3.3.
- Restriction to the use of NEMIS-specific Quality Measures (Annex E).
- Content controlled by NEMIS coconstraints that cannot be enforced using XSD – *e.g.*, requiring *msr:MD_GridSpatialRepresentation* attributes for gridded datasets but not point clouds.

The nemis.sch, nemisGmdProfileExclude.sch, and nemisGmdProfileRestrict.sch files may therefore be used in conjunction with an XSD-based NEMIS instance document structural conformance test.

G.4.4 Employing the NEMIS for validation

XML schemas developed for general use within the DoD/IC or for a specific community of interest are able to include or import (as appropriate) schemas directly from NSG Registry-hosted information resources. The following example illustrates how the schema location for the NEMIS schema is identified in an XML instance document being tested in a local-use development environment.

```
<?xml version="1.0" encoding="UTF-8"?>
<nas:MD_Metadata xmlns:nas="http://api.nsgreg.nga.mil/schema/nas/base19Jun"
```

```
xmlns:cit="http://standards.iso.org/iso/19115/-3/cit/2.0"
xmlns:gco="http://standards.iso.org/iso/19115/-3/gco/1.0"
xmlns:gex="http://standards.iso.org/iso/19115/-3/gex/1.0"
xmlns:lan="http://standards.iso.org/iso/19115/-3/lan/1.0"
xmlns:mcc="http://standards.iso.org/iso/19115/-3/mcc/1.0"
xmlns:mco="http://standards.iso.org/iso/19115/-3/mco/1.0"
xmlns:mdb="http://standards.iso.org/iso/19115/-3/mdb/2.0"
xmlns:mmi="http://standards.iso.org/iso/19115/-3/mmi/1.0"
xmlns:mrd="http://standards.iso.org/iso/19115/-3/mrd/1.0"
xmlns:mri="http://standards.iso.org/iso/19115/-3/mri/1.0"
xmlns:mrl="http://standards.iso.org/iso/19115/-3/mrl/2.0"
xmlns:mrs="http://standards.iso.org/iso/19115/-3/mrs/1.0"
xmlns:msr="http://standards.iso.org/iso/19115/-3/msr/2.0"
xmlns:mdq="http://standards.iso.org/iso/19157/-2/mdq/1.0"
xmlns:swe="http://www.opengis.net/swe/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:ism="urn:us:gov:ic:ism"
xmlns:ntk="urn:us:gov:ic:ntk"
xmlns:rr="urn:us:gov:ic:revrecall"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://api.nsgreg.nga.mil/schema/nemis/1.0.0 ./nemis.xsd"
ism:DESVersion="13"
ism:ISMCATCESVersion="13"
ntk:DESVersion="10"
rr:DESVersion="1"
ism:resourceElement="true" ism:createDate="2019-10-02" ism:classification="U"
ism:ownerProducer="USA" ism:compliesWith="USGov">

<!-- metadata content -->

</nas:MD_Metadata>
```

The NEMIS schema path is determined by the *xsi:schemaLocation* attribute value, which is composed of two strings. The first string in the example (http://api.nsgreg.nga.mil/schema/nemis/1.0.0) is the XML namespace. The second string (./nemis.xsd) is the relative resource path of the NEMIS schema definition document that may be used to validate the instance document. The two strings are separated by a space.

Note that values must be specified for the ism-, ntk-, and rr-namespace XML attributes in the case that content from those XML namespaces, respectively, is included in the XML instance document. The values of *ism:createDate* and *ism:classification* should be set appropriately; the other values are fixed in accordance with NEMIS requirements.

G.4.5 Resource-based Code Lists

In ISO 19115-1, some metadata elements with defined value domains are implemented as code lists. To support the code list construct, ISO/TS 19115-3 provides a mechanism for encoding values in a metadata instance using both a code list value and the identification of the code list in which the value is defined. The use of code lists in an XML instance document is described in NGA.STND.0012_3.0_NMIS, Annex B.2.3 (Code List Resources).

Code lists are instantiated by identifying a resource defined externally to the metadata instance. This resource specifies a standard set of values that may be referenced (and thus used) when populating a

metadata instance in order to ensure a consistent metadata encoding. The advantage of the code list is that the domain of values is defined external to the XML schema and can be restricted (or extended) without changing the XML schema – the metadata instance simply references the code list and one of its members.

Code list values are identified in an XML instance document by a URI. In practice, a URL is often used for the identifier. In the NEMIS, identifiers have been defined for each of the metadata code lists. The base URL for the NSG Registry code lists is http://api.nsgreg.nga.mil/codelist/. The full, unambiguous code list identifier is composed by concatenating this base URL with the NSG Standards Registry code list name. Note that the NAS code list name may be different than the ISO 19100-series spelling in the XSD, as the NAS drops the three-character prefix (*e.g.*, “MD_”, “CI_”, “GM_”).

The set of code lists that have been profiled for use by the NEMIS are listed in Annex D, which specifies the ISO 19100-series code list name (as used in the XSD), the authoritative NSG Standards Registry URL, and the list of allowed values. Some values which were not relevant to elevation metadata were removed to ensure greater clarity and consistency across the collection of NEMIS metadata instance documents.

G.5 Content-specific Encoding Guidelines

G.5.1 Introduction

Although the overall NEMIS XML Schema is clearly specified in the UML class diagrams and data dictionary of preceeding Annexes, there are several areas in which closer attention to nuances in the implementation of XML instance documents will be beneficial to the developer. These areas are addressed in subsequent sections.

G.5.2 XLink and Internal References

The ISO/TS 19115-3 XML schema implementation of ISO 19115-1 provides the option of encoding information in-line in a metadata instance element or providing a reference to an instance of a metadata element containing the information that is located elsewhere in the same instance document. This technique uses the XML Linking Language (XLink) (specifically the *xlink:href* XML attribute) to identify a local or remote instantiation of a metadata element. By using linking, a metadata instance can be more compact with fewer instances of identical information being repeated throughout the document.

One area within resource metadata where this can be of use is when citing a Responsible Party. For example, an instance of CI_Responsibility may be created for the metadata contact (*mdb:contact*) and then reused by reference to its unique value of XML attribute *xsd:id* when the same party is also the point of contact for the resource data (*mri:pointOfContact*). An example instance document is shown below, where the instance of *cit:CI_Organisation* that is the content of XML element *mdb:contact* is included by reference as the *cit:party* that is the content of XML elements *mri:pointOfContact* and *mrd:distributor*. The hash (“#”) prefix in the value of the *xlink:href* XML attribute indicates that the identifier is relative to the root of the XML instance document rather than referencing some XML element in a larger scope.

```
<?xml version="1.0" encoding="UTF-8"?>
<nas:MD_Metadata xmlns:nas="http://api.nsgreg.nga.mil/schema/nas/base19jun"
xmlns:cit="http://standards.iso.org/iso/19115/-3/cit/1.0"
```

```
xmlns:gco="http://standards.iso.org/iso/19115/-3/gco/1.0"
xmlns:mdb="http://standards.iso.org/iso/19115/-3/mdb/1.0"
xmlns:mrd="http://standards.iso.org/iso/19115/-3/mrd/1.0"
xmlns:mri="http://standards.iso.org/iso/19115/-3/mri/1.0"
xmlns:xlink="http://www.w3.org/1999/xlink">
  <!-- metadata content -->
  <mdb:contact>
    <cit:CI_Responsibility>
      <cit:role>
        <cit:CI_RoleCode codeList="http://api.nsgreg.nga.mil/codelist/RoleCode"
codeListValue="pointOfContact"/>
      </cit:role>
      <cit:party>
        <cit:CI_Organisation id="NGA">
          <cit:name>
            <gco:CharacterString>National Geospatial-Intelligence Agency
(NGA)</gco:CharacterString>
          </cit:name>
          <cit:contactInfo>
            <!-- a lot of contact details... -->
          </cit:contactInfo>
        </cit:CI_Organisation>
      </cit:party>
    </cit:CI_Responsibility>
  </mdb:contact>
  <!-- metadata content -->
  <mdb:identificationInfo>
    <nas:DataIdentification>
      <!-- metadata content -->
      <mri:pointOfContact>
        <cit:CI_Responsibility>
          <cit:role>
            <cit:CI_RoleCode
codeList="http://api.nsgreg.nga.mil/codelist/RoleCode"
codeListValue="pointOfContact"/>
          </cit:role>
          <cit:party xlink:href="#NGA"/>
        </cit:CI_Responsibility>
      </mri:pointOfContact>
      <!-- metadata content -->
    </nas:DataIdentification>
  </mdb:identificationInfo>
  <mdb:distributionInfo>
    <mrd:MD_Distribution>
      <!-- metadata content -->
      <mrd:distributor>
        <mrd:MD_Distributor>
          <mrd:distributorContact>
            <cit:CI_Responsibility>
              <cit:role>
                <cit:CI_RoleCode
codeList="http://api.nsgreg.nga.mil/codelist/RoleCode"
codeListValue="distributor"/>
              </cit:role>
              <cit:party xlink:href="#NGA"/>
            </cit:CI_Responsibility>
```

```
          </mrd:distributorContact>
        </mrd:MD_Distributor>
      </mrd:distributor>
      <!-- metadata content -->
    </mrd:MD_Distribution>
  </mdb:distributionInfo>
  <!-- metadata content -->
</nas:MD_Metadata>
```

G.5.3 References to External Resources

G.5.3.1 Code Lists

Code lists are instantiated by identifying a resource defined external to the metadata XML instance document. That resource specifies a well-known set of values that may be referenced when populating a metadata instance document. The advantage of the code list over an enumeration is that the domain of values is defined external to the XML schema and can thus be extended or restricted without changing the XML schema. Such a capability does, however, require that metadata producers and consumers ensure that they track such changes separate from new versions of the XML schema.

The NEMIS restricts the domain of values of some code lists in order to ensure greater consistency of use by metadata producers and to eliminate options incompatible with elevation metadata. CRS type (Annex D.8.2), spatial representation type (Annex D.5.3), and topic category code (Annex D.5.4) are all thus restricted in the NEMIS.

G.5.3.2 Coordinate Reference Systems

The NAS specifies the ability to describe the horizontal, vertical and temporal extent of a resource. In order to unambiguously specify horizontal and vertical extent and positions it is necessary to identify the spatial coordinate system to which a given extent and/or position is referenced.

The ISO/TS 19115-3 XML encoding employs the Geography Markup Language (GML) as its basis for defining the resource bounding polygon. GML defines the XML attribute *gml:srsName* in *gml:AbstractGML*, which uses a Uniform Resource identifier (URI) to reference an external resource that specifies the spatial reference system applicable to the positions of the vertices of the polygon. Similarly, a vertical CRS URI is referenced using the XML attribute *gex:verticalCRS* in *gex:EX_VerticalExtent*. Examples of external CRS references are provided in Annex G.5.8.

Specification of the CRS by reference to the externally-hosted NSG Spatiotemporal Reference Systems information resources (https://nsgreg.nga.mil/ir/registers.jsp?register=SRS) allows for dynamic support for new CRS resources independent of the evolution of the NEMIS schema and Schematron rules. Each time a new CRS is required by a NEMIS elevation data producer, NGA can add it to the NSG Registry, thereby making it immediately available to other data producers. It also avoids the complexity (and potential for error) caused by defining CRS identifiers using GML inside each metadata instance document.

G.5.4 Text Locale

Default text locale (encoded by *lan:PT_Locale*) is specified twice, both for the metadata (**Error! R eference source not found.**) and resource (Figure B-3): The following example specifies the default text

locale for the metadata (a combination of language, country, and a character encoding). These are the only values allowed in the NEMIS for metadata (*mdb:defaultLocale*). Metadata from foreign sources should be properly translated to maximize human readability and software compatibility across the NSG. However, if the dataset is of foreign origin (*e.g.*, a LAS file with German VLRs), the resource text locale (*mri:defaultLocale*) may have different values.

```
<mdb:defaultLocale>
  <lan:PT_Locale>
    <lan:language>
      <lan:LanguageCode
codeList="http://api.nsgreg.nga.mil/codelist/iso639-2" codeListValue="eng"/>
    </lan:language>
    <lan:country>
      <lan:CountryCode
codeList="http://api.nsgreg.nga.mil/N2L?" codeListValue="ge:GENC:3:3-11:USA"/>
    </lan:country>
    <lan:characterEncoding>
      <lan:MD_CharacterSetCode
codeList="http://api.nsgreg.nga.mil/codelist/IANACharset"
codeListValue="UTF-8"/>
    </lan:characterEncoding>
  </lan:PT_Locale>
</mdb:defaultLocale>
```

G.5.5 Classification and Other Constraints

Classification and security markings, access restrictions, and legal constraints are specified using the UML classes shown in Figure B-4. The following XML example describes an unclassified dataset with access governed by the U.S. Privacy Act and Limited Distribution (LIMDIS) dissemination controls. The SRTM source reference is documented because source datasets often come with their own restrictions. Data access is subject to license terms and an end user license agreement is referenced; that agreement (file) should be accessible to the user. It is also possible to directly include the license terms in the *mco:otherConstraints* CharacterString accompanying the “license” *mco:MD_RestrictionCode*.

Note that the classifications for metadata (XML document) and resource (elevation dataset) may be different. For example, the data may be classified but with unclassified metadata that does not describe sensitive aspects of the data. Alternatively, some unclassified elevation products contain classified metadata (*e.g.*, accuracy and source image information). In the latter case, it is necessary to create both classified and unclassified XML documents in order to distribute the products on all security domains.

```
<mri:resourceConstraints>
  <nas:ResourceConstraints ism:classification="U" ism:ownerProducer="USA"
ism:nonICmarkings="DS">
    <nas:notice ism:classification="U" ism:ownerProducer="USA"
ism:noticeDate="2010-09-21" ism:noticeType="DS">
      <ism:NoticeText ism:classification="U" ism:ownerProducer="USA">
Distribution authorized to DoD, IAW 10 U.S.C. Section 130 and Section 455.
Release authorized to U.S. DoD contractors IAW 48 C.F.R. Section 252.245-7000.
Refer other requests to: Headquarters, NGA, ATTN: Release Officer, Mail Stop
S82-OIAD, 7500 GEOINT Drive, Springfield, VA 22150. Destroy IAW DoDD 5030.59.
Removal of this caveat is prohibited.</ism:NoticeText>
```

```
    </nas:notice>
  </nas:ResourceConstraints>
</mri:resourceConstraints>
<mri:resourceConstraints>
  <mco:MD_LegalConstraints>
    <mco:accessConstraints>
      <mco:MD_RestrictionCode
codeList="http://api.nsgreg.nga.mil/codelist/RestrictionCode"
codeListValue="usPrivacyAct"/>
    </mco:accessConstraints>
    <mco:otherConstraints>
      <gco:CharacterString>
SRTM data were used to create this dataset: NASA JPL (2013). NASA Shuttle Radar
Topography Mission Global 1 arc second [Data set]. NASA EOSDIS Land Processes
DAAC. doi: 10.5067/MEaSUREs/SRTM/SRTMGL1.003</gco:CharacterString>
    </mco:otherConstraints>
  </mco:MD_LegalConstraints>
</mri:resourceConstraints>
<mri:resourceConstraints>
  <mco:MD_LegalConstraints>
    <mco:accessConstraints>
      <mco:MD_RestrictionCode
codeList="http://api.nsgreg.nga.mil/codelist/RestrictionCode"
codeListValue="license"/>
    </mco:accessConstraints>
    <mco:otherConstraints>
      <gco:CharacterString>License terms and conditions apply. See end user
license agreement document.</gco:CharacterString>
    </mco:otherConstraints>
  </mco:MD_LegalConstraints>
</mri:resourceConstraints>
```

G.5.6 Data Distribution

Distribution information is specified using the UML classes shown in Figure B-5. This example describes a 214.6 MB GeoTIFF conforming to the DGIWG-108 standard. It is distributed by NGA through the Geospatial Repository and Data Management System (GRiD). An *xlink:href* XML attribute (Annex G.5.2) references a local instantiation of *cit:CI_Organisation* (not shown) whose XML attribute *xsd:id* has the value “NGA”.

```
<mdb:distributionInfo>
  <mrd:MD_Distribution>
    <mrd:distributionFormat>
      <mrd:MD_Format>
        <mrd:formatSpecificationCitation>
          <cit:CI_Citation>
            <cit:title>
              <gco:CharacterString>Geographic Tagged Image File Format
(GeoTIFF)</gco:CharacterString>
            </cit:title>
            <cit:edition>
              <gco:CharacterString>2.2.1</gco:CharacterString>
            </cit:edition>
            <cit:identifier>
```

```
              <mcc:MD_Identifier>
                <mcc:authority>
                  <cit:CI_Citation>
                    <cit:title>
                      <gco:CharacterString>DGIWG-108</gco:CharacterString>
                    </cit:title>
                    <cit:alternateTitle>
                      <gco:CharacterString>GeoTIFF Profile for Georeferenced
Imagery</gco:CharacterString>
                    </cit:alternateTitle>
                    <cit:date>
                      <cit:CI_Date>
                        <cit:date>
                          <gco:DateTime>2017-12-08T00:00:00Z</gco:DateTime>
                        </cit:date>
                        <cit:dateType>
                          <cit:CI_DateTypeCode
codeList="http://api.nsgreg.nga.mil/codelist/DateTypeCode"
codeListValue="revision"/>
                        </cit:dateType>
                      </cit:CI_Date>
                    </cit:date>
                  </cit:CI_Citation>
                </mcc:authority>
                <mcc:code>
                  <gco:CharacterString>TIFF</gco:CharacterString>
                </mcc:code>
                <mcc:description>
                  <gco:CharacterString>signed 32-bit floating point (-32768 to
32767)</gco:CharacterString>
                </mcc:description>
              </mcc:MD_Identifier>
            </cit:identifier>
          </cit:CI_Citation>
        </mrd:formatSpecificationCitation>
      </mrd:MD_Format>
    </mrd:distributionFormat>
    <mrd:distributor>
      <mrd:MD_Distributor>
        <mrd:distributorContact>
          <cit:CI_Responsibility>
            <cit:role>
              <cit:CI_RoleCode
codeList="http://api.nsgreg.nga.mil/codelist/RoleCode"
codeListValue="distributor"/>
            </cit:role>
            <cit:party xlink:href="#NGA"/>
          </cit:CI_Responsibility>
        </mrd:distributorContact>
      </mrd:MD_Distributor>
    </mrd:distributor>
    <mrd:transferOptions>
      <mrd:MD_DigitalTransferOptions>
        <mrd:unitsOfDistribution>
          <gco:CharacterString>MB</gco:CharacterString>
        </mrd:unitsOfDistribution>
```

```
        <mrd:transferSize>
          <gco:Real>214.6</gco:Real>
        </mrd:transferSize>
        <mrd:onLine>
          <cit:CI_OnlineResource>
            <cit:linkage>
              <gco:CharacterString>https://grid.nga.mil</gco:CharacterString>
            </cit:linkage>
            <cit:name>
              <gco:CharacterString>Geospatial Repository and Data Management
System (GRiD)</gco:CharacterString>
            </cit:name>
          </cit:CI_OnlineResource>
        </mrd:onLine>
      </mrd:MD_DigitalTransferOptions>
    </mrd:transferOptions>
  </mrd:MD_Distribution>
</mdb:distributionInfo>
```

G.5.7 Grid Spatial Representation

Spatial representation information for gridded elevation data is specified using the UML classes shown in Figure B-6. In gridded elevation data, exactly two axis dimensions are required ("row" and "column"), with the unit, resolution, and number of intervals specified for each.

As a best practice, *msr:cellGeometry* should be "point," indicating that the value matches the elevation at the center of the grid cell, not at one of its edges. The value for *msr:transformationParameterAvailability* must be "true", indicating that the reference system parameters are sufficiently well known that the grid can be transformed into other coordinate systems. If this is not the case (*e.g.*, for elevation data in local coordinate systems), the resource should not be distributed by NGA.

Note that the spatial representation classes do not apply to point cloud data. Instead, point cloud spacing/density and tiling properties should be encoded in the file header or other auxiliary files using the custom metadata attributes specified in Section **6.2.4**.

```
<mdb:spatialRepresentationInfo>
  <msr:MD_GridSpatialRepresentation>
    <msr:numberOfDimensions>
      <gco:Integer>2</gco:Integer>
    </msr:numberOfDimensions>
    <msr:axisDimensionProperties>
      <msr:MD_Dimension>
        <msr:dimensionName>
          <msr:MD_DimensionNameTypeCode
codeList="http://api.nsgreg.nga.mil/codelist/DimensionNameTypeCode"
codeListValue="row"/>
        </msr:dimensionName>
        <msr:dimensionSize>
          <gco:Integer>1001</gco:Integer>
        </msr:dimensionSize>
        <msr:resolution>
          <gco:Measure
uom="http://api.nsgreg.nga.mil/physical-quantity/length/metre">2.0</gco:Measure>
```

```
        </msr:resolution>
      </msr:MD_Dimension>
    </msr:axisDimensionProperties>
    <msr:axisDimensionProperties>
      <msr:MD_Dimension>
        <msr:dimensionName>
          <msr:MD_DimensionNameTypeCode
codeList="http://api.nsgreg.nga.mil/codelist/DimensionNameTypeCode"
codeListValue="column"/>
        </msr:dimensionName>
        <msr:dimensionSize>
          <gco:Integer>1001</gco:Integer>
        </msr:dimensionSize>
        <msr:resolution>
          <gco:Measure
uom="http://api.nsgreg.nga.mil/physical-quantity/length/metre">2.0</gco:Measure>
        </msr:resolution>
      </msr:MD_Dimension>
    </msr:axisDimensionProperties>
    <msr:cellGeometry>
      <msr:MD_CellGeometryCode
codeList="http://api.nsgreg.nga.mil/codelist/CellGeometryCode"
codeListValue="point"/>
    </msr:cellGeometry>
    <msr:transformationParameterAvailability>
      <gco:Boolean>true</gco:Boolean>
    </msr:transformationParameterAvailability>
  </msr:MD_GridSpatialRepresentation>
</mdb:spatialRepresentationInfo>
```

G.5.8 Geographic Extent

Geographic extent is reported using the UML classes shown in Figure B-7.

The geographic extent reported in the metadata may be specified either as a bounding box (eastern- and western-most longitude and northern- and southern-most latitude), a bounding polygon, or as a description (text). The extent may be reported using multiple representations, simultaneously. At a minimum, the NEMIS requires that geographic extent be encoded as a bounding box. Although specifying a more detailed extent using a polygon is optional, it is a recommended best practice for point clouds, gridded datasets in projected coordinate systems, and datasets containing voids (in which case voids should be defined using interior rings). Text descriptions may be useful in some cases (*e.g.*, tactical scenarios).

The extent reported using *gex:geographicElement* shall be the horizontal extent only. The coordinate reference system for the positions of the horizontal extent is specified using the XML attribute *gml:srsName*. Mechanisms for identifying specific coordinate reference systems are specified in Annex D.8.3.

The bounding polygon representation directly uses ISO 19136, Geography Markup Language (GML), as defined by OGC 07-036r1. For the bounding polygon, the object *gml:Polygon* is used to contain the positions making up the exterior boundary of the polygon and the interior boundar(ies), if any. Interior rings are used to indicate “holes” in the area bounded by the exterior ring that are to be specifically

excluded from search and discovery for the resource content. For example, interior rings could indicate areas of no data (voids) or areas of poor reliability (where the data is unreliable and should be replaced with other sources, if available). Metadata authors are advised to consult the specific guidance for their product specification in order to determine whether interior rings should be specified in the geographic extent of their metadata.

The following example illustrates a bounding polygon instance which has two holes.

```
<gex:geographicElement>
  <gex:EX_BoundingPolygon>
    <gex:polygon>
      <gml:Polygon gml:id="DGEDpolygon"
srsName="https://api.nsgreg.nga.mil/coord-ref-system/WGS84E_UTM06N">
        <gml:exterior>
          <gml:LinearRing>
            <gml:pos>346706.2 6715638.5</gml:pos>
            <gml:pos>346706.2 6717605.2</gml:pos>
            <gml:pos>348685.6 6717605.2</gml:pos>
            <gml:pos>348685.6 6715638.5</gml:pos>
            <gml:pos>346706.2 6715638.5</gml:pos>
          </gml:LinearRing>
        </gml:exterior>
        <gml:interior>
          <gml:LinearRing>
            <gml:pos>347166.9 6717082.3</gml:pos>
            <gml:pos>347734.2 6717072.4</gml:pos>
            <gml:pos>348055.5 6716757.8</gml:pos>
            <gml:pos>347910.1 6716409.9</gml:pos>
            <gml:pos>347509.2 6716348.0</gml:pos>
            <gml:pos>347007.4 6716653.9</gml:pos>
            <gml:pos>347166.9 6717082.3</gml:pos>
          </gml:LinearRing>
        </gml:interior>
        <gml:interior>
          <gml:LinearRing>
            <gml:pos>348408.8 6716027.8</gml:pos>
            <gml:pos>348462.0 6716045.2</gml:pos>
            <gml:pos>348471.0 6716025.0</gml:pos>
            <gml:pos>348421.7 6716008.0</gml:pos>
            <gml:pos>348408.8 6716027.8</gml:pos>
          </gml:LinearRing>
        </gml:interior>
      </gml:Polygon>
    </gex:polygon>
  </gex:EX_BoundingPolygon>
</gex:geographicElement>
```

G.5.9 Vertical Extent

Vertical extent is reported using the UML classes shown in Figure B-7. Although the vertical extent metadata element is optional, it is highly recommended. Vertical extent is an important component of a dataset's spatial position and the minimum-maximum range can be used to detect data anomalies in comparison to overlapping datasets.

Vertical extent shall be specified using *gex:verticalElement*, The coordinate reference system for the vertical CRS is specified using the XML attribute *xlink:href*, which stores a URI specifying a CRS defined in the NSG Standards Registry. Mechanisms for identifying specific coordinate reference systems are specified in Annex D.8.3.

The following example is of an elevation dataset with values between 0 (sea level) and 1875.99 m. Note that the unit of measure is not specified in the metadata, because it is part of the external "EGM96_H" reference.

```
<gex:verticalElement>
  <gex:EX_VerticalExtent>
    <gex:minimumValue>
      <gco:Real>0.00</gco:Real>
    </gex:minimumValue>
    <gex:maximumValue>
      <gco:Real>1875.99</gco:Real>
    </gex:maximumValue>
    <gex:verticalCRS
xlink:href="http://api.nsgreg.nga.mil/coord-ref-system/EGM96_H"/>
  </gex:EX_VerticalExtent>
</gex:verticalElement>
```

G.5.10 Temporal Extent

Temporal extent is reported using the UML classes shown in Figure B-7.

Temporal extents reported in NAS-conformant metadata are instantiated in an XML instance document using ISO 19136 (OGC 07-036r1). Primarily, the temporal extent will be reported as either a closed period (both the beginning and ending times are reported), an open period (only either the beginning or ending times reported) or as an instant (*i.e.*, a date, or a date and time).

The GML objects used to report temporal extent in the NEMIS are *gml:TimeInstant* and *gml:TimePeriod*. A closed period uses the *gml:TimePeriod* object with a date and/or time specified for both *gml:begin* (start of the period) and *gml:end* (end of the period). It is a recommended practice that *gml:TimeInstant* not be used with a specified value of indeterminatePosition unless it is being used to specify an open-ended temporal extent using *gml:TimePeriod* (see Section 8.6.2). Doing so results in consistent XML representation of the related semantics "before" and "on or before" (as well as "after" and "on or after") as syntactically-consistent temporal extents. It also eliminates inconsistent modelling choices for open-ended temporal extents by different developers.

```
<gex:temporalElement>
  <gex:EX_TemporalExtent>
    <gex:extent>
      <gml:TimePeriod gml:id="ImageDateRange">
        <gml:begin>
          <gml:TimeInstant gml:id="FirstImage">
            <gml:timePosition>2011-05-11T01:23:02Z</gml:timePosition>
          </gml:TimeInstant>
        </gml:begin>
        <gml:end>
          <gml:TimeInstant gml:id="LastImage">
```

```
            <gml:timePosition>2014-09-13T01:26:15Z</gml:timePosition>
          </gml:TimeInstant>
        </gml:end>
      </gml:TimePeriod>
    </gex:extent>
  </gex:EX_TemporalExtent>
</gex:temporalElement>
```

The content of *gml:timePosition* can express a temporal value in multiple ways. The content model used is an *xs:union* of many XML simple types, of which two are supported in the NEMIS: *xs:date* and *xs:dateTime* (Annex C.2).

When specifying a time instant, a degree of precision should be used that is consistent with applicable business practices. However, in the context of enterprise-wide search it is necessary to ensure that a consistent interpretation of reduced-precision values of *gml:timePosition* is shared. To this end, the following rules shall be observed:

3. The dates and times reported for a time period shall be inclusive in the period.
4. The reported time shall be based on Universal Time (UTC), indicated by appending the capital letter Z (meaning the “zero meridian”) to the time specification.

A time instant may be used as the content of a temporal extent in order to indicate a specific date/time, *e.g.* the moment one image in a stereopair is captured. The following example records a time instant (18 July 2018 at 06:25:33 UTC).

```
<gex:temporalElement>
  <gex:EX_TemporalExtent>
    <gex:extent>
      <gml:TimeInstant gml:id="ImageTime">
        <gml:timePosition>2018-07-18T06:25:33.47Z</gml:timePosition>
      </gml:TimeInstant>
    </gex:extent>
  </gex:EX_TemporalExtent>
</gex:temporalElement>
```

G.5.11 Data Quality – Positional Accuracy

Data Quality results are reported using the UML classes shown in Figure B-9. This can include an optional reference to one or more external quality reports (*e.g.*, a PDF file with an independent audit or an Excel spreadsheet with detailed statistics).

The following example illustrates the use of *mdq:DQ_QuantitativeResult* to record the absolute vertical error, Linear Error at the 90% probability level ($LE90_{ABS}$). In the example, the *mdq:DQ_DataQuality* section has been abbreviated to exclude the mandatory data quality scope and additional data quality reports.

```
<mdb:dataQualityInfo>
  <mdq:DQ_DataQuality>

    <!-- data quality scope -->
```

```
    <mdq:report>
      <mdq:DQ_AbsoluteExternalPositionalAccuracy>
        <mdq:result>
          <mdq:DQ_QuantitativeResult>
            <mdq:value>
              <gco:Record>
                <swe:Quantity
definition="http://api.nsgreg.nga.mil/qual-measure/LinearMapAccuracy90">
                  <swe:label>Absolute LE90</swe:label>
                  <swe:uom
xlink:href="http://api.nsgreg.nga.mil/physical-quantity/length/metre"/>
                  <swe:value>2.0</swe:value>
                </swe:Quantity>
              </gco:Record>
            </mdq:value>
          </mdq:DQ_QuantitativeResult>
        </mdq:result>
      </mdq:DQ_AbsoluteExternalPositionalAccuracy>
    </mdq:report>

    <!-- other data quality reports -->

  </mdq:DQ_DataQuality>
</mdb:dataQualityInfo>
```

G.5.12 Data Quality – Topological Consistency

The Topological Consistency category of data quality is specified using the UML classes shown in Figure B-9. This is an example use case of *mdq:DQ_TopologicalConsistency* to describe the edge matching result for the eastern edge of the tile. The edge-matching report uses two results: *mdq:DQ_ConformanceResult* to indicate whether the test passed or failed, and *mdq:DQ_QuantitativeResult* to indicate the number of non-matching points. In this example, the test passed so the second value is zero.

```
<mdq:report>
  <mdq:DQ_TopologicalConsistency>
    <mdq:measure>
      <mdq:DQ_MeasureReference>
        <mdq:nameOfMeasure>
          <gco:CharacterString>Edge Matching East</gco:CharacterString>
        </mdq:nameOfMeasure>
        <mdq:measureDescription>
          <gco:CharacterString>Describes the edge matching result for the
eastern neighbor. Element mdq:pass is set to 1 if the neighboring tile was
available for testing. Element mdq:value indicates the number of non matching
posts.</gco:CharacterString>
        </mdq:measureDescription>
      </mdq:DQ_MeasureReference>
    </mdq:measure>
    <mdq:result>
      <mdq:DQ_ConformanceResult>
        <mdq:specification>
```

```
          <cit:CI_Citation>
            <cit:title>
              <gco:CharacterString>NGA.SIG.0033_1.0_ELEV</gco:CharacterString>
            </cit:title>
            <cit:date>
              <cit:CI_Date>
                <cit:date>
                  <gco:DateTime>2019-07-07T00:00:00Z</gco:DateTime>
                </cit:date>
                <cit:dateType>
                  <cit:CI_DateTypeCode
codeList="http://api.nsgreg.nga.mil/codelist/DateTypeCode"
codeListValue="publication"/>
                </cit:dateType>
              </cit:CI_Date>
            </cit:date>
          </cit:CI_Citation>
        </mdq:specification>
        <mdq:pass>
          <gco:Boolean>1</gco:Boolean>
        </mdq:pass>
      </mdq:DQ_ConformanceResult>
    </mdq:result>
    <mdq:result>
      <mdq:DQ_QuantitativeResult>
        <mdq:value>
          <gco:Record>
            <swe:Quantity definition="undefined">
              <swe:label>Non-matching Points</swe:label>
              <swe:uom
xlink:href="http://api.nsgreg.nga.mil/physical-quantity/pureNumber/unitless"/>
              <swe:value>0</swe:value>
            </swe:Quantity>
          </gco:Record>
        </mdq:value>
      </mdq:DQ_QuantitativeResult>
    </mdq:result>
  </mdq:DQ_TopologicalConsistency>
</mdq:report>
```

G.5.13 Data Quality – Completeness

The Completeness category of data quality is specified using the UML classes shown in Figure B-9. This is an example use case of *mdq:DQ_CompletenessCommission* to describe the percentage of the cell that was void-filled with lower-resolution SRTM data. It can also be used to describe, *e.g.*, the total data coverage (area free of voids), content checked for accuracy, availability of control points, etc.

```
<mdq:report>
  <mdq:DQ_CompletenessCommission>
    <mdq:measure>
      <mdq:DQ_MeasureReference>
        <mdq:nameOfMeasure>
          <gco:CharacterString>SRTM Void Fill</gco:CharacterString>
        </mdq:nameOfMeasure>
```

```
        <mdq:measureDescription>
          <gco:CharacterString>Percentage of the cell for which SRTM data was
used to fill voids</gco:CharacterString>
        </mdq:measureDescription>
      </mdq:DQ_MeasureReference>
    </mdq:measure>
    <mdq:result>
      <mdq:DQ_QuantitativeResult>
        <mdq:value>
          <gco:Record>
            <swe:Quantity definition="undefined">
              <swe:label>SRTM Void Fill</swe:label>
              <swe:uom
xlink:href="http://api.nsgreg.nga.mil/physical-quantity/pureNumber/percent"/>
              <swe:value>100</swe:value>
            </swe:Quantity>
          </gco:Record>
        </mdq:value>
      </mdq:DQ_QuantitativeResult>
    </mdq:result>
  </mdq:DQ_CompletenessCommission>
</mdq:report>
```

Bibliography

The following references are informative only. They support but do not supersede the references cited in Section 2.

Standard or Specification
DGIWG – 108, GeoTIFF Profile for Georeferenced Imagery (STD-DP-08-089r3), Edition 2.2.1 (8 December 2017): https://portal.dgiwg.org/files/?artifact_id=68102
DGIWG – 114: DGIWG Metadata Foundation (DMF) (STD-DP-17-008), Edition 2.0 (12 July 2017): https://portal.dgiwg.org/files/?artifact_id=67565
DGIWG – 116-1: Elevation Surface Model Standardized Profile (STD-DP-13-005r2), Edition 1.1.0 (19 October 2017): https://portal.dgiwg.org/files/?artifact_id=68103
ISO 8601-1:2019, Date and time format – Part 1: Basic rules: https://www.iso.org/iso-8601-date-and-time-format.html
ISO 19103:2015, Geographic information – Conceptual schema language: https://www.iso.org/standard/56734.html
ISO 19107:2003, Geographic information – Spatial schema: https://www.iso.org/standard/66175.html
ISO 19108:2002, Geographic information – Temporal schema: https://www.iso.org/standard/26013.html
ISO 19111:2019, Geographic information – Referencing by coordinates: https://www.iso.org/standard/74039.html
NGA.IP.0002_1.1, Implementation Profile for High Resolution Elevation (HRE) Products, Version 1.1 (2014-04-15): https://nsgreg.nga.mil/doc/view?i=1782
NGA.STND.0054-1_1.0_SIPCDIDD, Sensor Independent Point Cloud (SIPC), Volume 1: Design and Implementation Description Document (20 October 2015): https://nsgreg.nga.mil/doc/view?i=4206
NGA.STND.0054-2_1.0_SIPCFFDD, Sensor Independent Point Cloud (SIPC), Volume 2: File Format Description Document (20 October 2015): https://nsgreg.nga.mil/doc/view?i=4207
NGA.STND.0055-01_1.0_MIPCDIDD, Modality Independent Point Cloud, Volume 1: Design and Implementation Description Document (8 June 2016): https://nsgreg.nga.mil/doc/view?i=4246
NGA.STND.0055-02_1.0_MIPCFFDD, Modality Independent Point Cloud, Volume 2: File Format Description Document (8 June 2016): https://nsgreg.nga.mil/doc/view?i=4247
NSG LiDAR Interoperability Guide: Key Recommendations for LiDAR Product Quality and Utility, Version 2.2 (19 July 2018)
STDI-0002, The Compendium of Controlled Extensions (CE) for the National Imagery Transmission Format (NITF), Appendix Z: General Electro-Optical (Visible, Infrared, Multi- and Hyperspectral) Sensor Parameters (SENSRB) Tagged Record Extension (TRE), Version 2.1 (December 2013): https://gwg.nga.mil/ntb/baseline/docs/stdi0002/stdi0002_v40/SENSRB%20Appendix%20Z%20Dec%202013.pdf
USGS LiDAR Base Specification, Techniques and Methods 11–B4, Version 1.3 (February 2018): https://pubs.usgs.gov/tm/11b4/pdf/tm11-B4.pdf
XML Schema Part 2: Datatypes, Second Edition (28 October 2004): https://www.w3.org/TR/xmlschema-2/